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Development of the Russian Picture-Identification test

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ABSTRACT

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In the multi-cultural environment of today's audiological clinic, the need for a valid instrument for assessing the word recognition abilities of native speakers of other languages is becoming imperative. Such a instrument labeled as a Picture-Identification task, utilizes the auditory/visual format, in which a word recognition test is administered and scored automatically using a language-to-place transformation on a computer monitor, obviating the need for an audiologist to share a language with a patient.

In the current study, auditory and visual portions of the Picture-Identification Task in the Russian language were designed and implemented. Normative performance of twenty-one normal hearing native speakers of Russian was obtained in open-set oral response conditions and closed-set picture-pointing conditions intended for clinical use. Psychometric functions provided for the norms for clinical decision making. Performance was analyzed in the context of similar tests in English and Spanish and demonstrated good correlation with these tests.

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DEDICATION

To the pain and tears of my mother dedicated

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Chapter I

Introduction

In todays' complex and multi-cultural world, the ability to serve populations from different cultural backgrounds is becoming increasingly important for a successful clinical practice. Audiologists frequently are confronted with the necessity to perform audiologic evaluations on individuals who have no or limited knowledge of English. A standard audiological battery includes supra-threshold word recognition tests that require the patient to repeat words presented at a comfortable level. Originally developed to test communications systems (i.e., in aircraft, etc.) in the late 1940's, word recognition tests soon were applied to assess human communication, and are currently used for the following purposes: a) to estimate the degree of hearing or communicative handicap of the patient, b) to determine the anatomical site of lesion, c) to monitor progress in aural rehabilitation, and d) to assess hearing aid performance (Silverman and Silman, 1991). Because conventional word-recognition tests require some type of linguistic interaction between the clinician and the patient and the client's knowledge of the language of the test, information regarding the hearing acuity for speech for non-English speakers is difficult to obtain using conventional English materials.

The standard oral-response paradigm for word recognition tests has been modified to eliminate the direct linguistic interaction between the audiologist and patient. Here, the oral response has been replaced by a pointing response. This modification, labeled Picture-Identification Task (PIT), was initially developed to assess the word-recognition abilities of non-verbal adults (Wilson and Antablin, 1980) and later modified to address the needs of the native speakers of Spanish (McCullough et al., 1995). In this format, auditory target words in the patient's native language are initiated by the audiologist using a menu on a computer monitor in the control room. The target word is presented through earphones to the patient in the test room, who is seated in front of a monitor on which four pictures corresponding to the target word and three rhyming alternatives (a response foil) are displayed. The patient points or clicks with the computer mouse on the picture representing the target word. Thus, the test is administered and scored automatically using a simple language-to-place transformation on a computer monitor, obviating the need for an audiologist to share the common language with a patient.

In 1993, McCullough et al., described a multimedia implementation of the Picture-Identification Task for the assessment of the multi-lingual population, using prototype Spanish materials. The present study is part of a broader project, aimed at providing the clinical audiologist with the computerized Picture-Identification Task test in variety of languages, thus enabling the clinician to draw reliable information pertaining to the supra-threshold word recognition ability of a foreign language speaker. The study addresses the needs of the Russian language-speaking community and the clinicians working with them. Since the demise of the Soviet Union, a significant number of Russian émigrés have entered the United States. Major centers of emigrant population include New York City, Los Angeles, Boston and the San Francisco Bay Area. In these centers, audiologists routinely encounter Russian patients, and the need for a valid Russian word recognition test is evident.

The present study involved the construction and standardization of the Russian Picture-Identification Task

(RPIT) in the multi-media format. Specifically, the first part of this project consisted of selecting monosyllabic and bisyllabic rhyming target word alternatives and implementing auditory (target word recordings) and visual (picture response plates) portions of the test. Secondly, a description of the performance of young normal-hearing Russian speakers was obtained in open-set (auditory stimulation, oral/written response) and closed-set (auditory stimulation, picture-pointing four-alternative forced-choice response) conditions. An analysis of normative performance and error patterns was undertaken by calculating psychometric functions from data obtained in the open- and close-set conditions. Further, a comparison of the normative performance of the Russian speakers on the Russian Picture-Identification Task to the performance of English and Spanish was made. The results indicate that English-speaking audiologists may use the Russian materials to estimate the word-recognition abilities of the Russian-speaking clinical population.

Chapter II

Review of the Literature

In clinical practice and in the psychoacoustic laboratory alike, the accuracy of cross-language speech perception and its implications for audiological practice has been discussed since the early 1970s. In clinical practice, the assessment of word recognition performance of the non-native speakers of English has often been excluded from the test battery (Grace, 1992). The need for a valid cross-language word recognition assessment instrument was long recognized (McCullough, 1993). Recently, the existing protocol for assessing speech recognition and perception at threshold and supra-threshold levels in English has been modified to assess the speech perception of native speakers of other languages, both by native-speaking and English-speaking audiologists. The test items were designed to represent phonetic and phonological properties of the language, and different protocols were employed to minimize error-laden linguistic interactions of an English-speaking audiologist and a non-English speaking audiological patient.

The present review of the literature provides a theoretical framework for the possible mechanisms of cross-language speech perception. These mechanisms are discussed in the context of the audiological clinic, in which obtaining valid measurements of word recognition abilities of the non-native speaker by an English-speaking audiologist would be rendered difficult by the language barrier. Since the Picture-Identification Task format offers a unique solution to this problem, the discussion is followed by an overview of the implementations of the picture-pointing task paradigm as a test design aimed at minimizing clinician/patient linguistic interaction.

Finally, an overview of the literature on the test items' selection for word recognition tasks and the picture-pointing paradigm concludes this review of the literature. The publications reviewed in this chapter provided the theoretical foundations of the present study.

Cross-Language Speech Perception

Interest in the role of language experience in speech perception has been growing steadily since the first studies of the cross-language speech perception were reported in the early 1970's (Polka, 1995). The studies have shown that adults often have difficulty discriminating and identifying syllables that differ in a single non-native phonological distinctive feature when tested with both natural speech and synthesized speech continua (Polka, 1991, 1995).

In the study conducted by Polka (1991), 18 monolingual, American English-speaking undergraduate students with normal hearing and no phonetics training were asked to discriminate 180 CV syllables with eight different Hindi stop consonants and the same vowel, presented in pairs. The stimuli constituted allophonic variations of the Hindi retroflex versus dental place-of-articulation contrasting consonants in four phonemically different voicing contexts. The subjects were instructed to indicate that the stimulus pair was the "same," when two consonants belonged to the same category (i.e., retroflex), and "different," when two consonants belonged to the two contrasting categories (i.e., retroflex versus dental). The voicing context was systematically varied between presentations. The results showed that for no contrast the performance reached the "native-like" accuracy, yet the overall correct performance differed for various voicing contexts. Subjects reported "translating" the stimuli into English and making comparison judgments based on the perceived English equivalents. This phenomenon was labeled as the "assimilation" process. The performance of the subjects was substantially better than chance (80 percent correct) for the "voiceless unaspirated" context, which is most phonemically relevant for native speakers of English, and was at the chance level (50 percent correct) for the "prevoiced" context, for which no equivalent exists in English. This perceptual advantage for native (phonemic) over non-native (nonphonemic) contrasts demonstrated that adult speech perception is organized to process the native language with the greatest efficiency and least effort. The study also demonstrated that language-specific influences were more evident in perception of some non-native contrasts than in others.

Best (1993) postulated that adults perceptually assimilate non-native contrasts to the phonemic categories of their native language whenever possible, with the direction and degree of assimilation being determined by phonetic similarities between native and non-native phones. Another study conducted by Polka (1995) illustrated the process of assimilation of the German lax-tense and rounded-back vowel contrasts into English. It had been hypothesized that English listeners might have difficulty discriminating German front-rounded versus back-rounded vowel contrasts because English does not have a phonemic distinction between high front versus back vowels that is independent of lip-rounding differences. Ten monolingual English-speaking subjects were asked to indicate two identical CVC syllables in the presented triad (the task involved indicating which syllable, i.e., first or last, matched the middle syllable). The middle syllable was not physically identical to the syllable that it matched in the triad; it was a different instance of the same vowel category. Thus subjects were required to make a vowel category match rather than an exact acoustic match. The response was timed. Then subjects were asked to indicate the English vowel most similar to the vowel in the given German syllable. The results indicated that, although English listeners were highly accurate in discriminating and identifying German vowels (86% and above), they made more errors and had longer and more variable response times in discriminating the German lax vowel contrast than in discriminating the German tense vowels, which were reported as perceived closer to the English equivalents in the second part of the experiment. The assimilation pattern was described by the author as a "category goodness difference" assimilation, where German vowel contrasts nonphonemic in English were perceived as "good" and "less good" exemplars of a single English category.

In a similar study, Gottfried (1984) reported that when categorizing CV syllables by vowel contrasts, 10 native speakers of English were less accurate than 10 French-speaking subjects when the contrasts were phonemic in French, but not in English, with the performance evening out when the contrasts were phonemic in both languages.

In a series of studies reported by Flege et al., (Bohn and Flege, 1990; Flege, Munro and Fox, 1994; Fox, Flege and Munro, 1995), the perception of the English and Spanish vowels by the speakers of one or both of these languages was examined in light of the cross-language vowel perception. In 1989 study (Bohn and Flege, 1990), 20 native speakers of Spanish (10 without any knowledge of English and 10 with some knowledge of English) were asked to identify the vowels in the English words "beat," "bit," "bet" and "bat" using letters "i, e, a, o, u" or to respond "none" if they did not hear a Spanish vowel. Subjects who could speak English responded "none" significantly more often than Spanish monolinguals for all four words, suggesting that they had begun to differentiate the English vowels from their nearest phonemic counterpart in Spanish. In the second series of the experiments, the same subjects were asked to identify the members of the vowel continua which varied spectrally (11 steps). Like native speakers, most Spanish subjects showed clear crossover borderlines when identifying stimuli ranging from "bet" to "bat," probably because the endpoints were identified with different Spanish vowels (i.e., /e/ and /a/). Only 30% of the subjects showed clearly defined cross-overs for a "bit"-to-"beat" continuum, probably because the endpoints were identified as a single Spanish vowel /i/. The experience in English appeared uncorrelated with this result. The result, therefore, indicated that even experienced Spanish speakers of English may not establish categorical perception for the contrasts that are nonphonemic in their native language.

Cross-language perception of vowels was often reported to demonstrate the pattern contrasting with consonantal perception: the categorization of vowels appeared to be more accurate for within-category vowels than for consonants.

Isolated vowel identification also appeared to be less prone to confusion than isolated consonant identification. These differences were hypothesized to support the theory of dual coding of speech in both the auditory code and the phonetic category code, with vowels favoring auditory code and consonants, due to their acoustic properties (brevity, small and rapid spectral change), yielding more readily to the phonemic category code (Studdert-Kennedy, 1993). Polka (1995) found that English listeners' mapping of German vowel to English vowel categories could be characterized as a category goodness difference assimilation, thus failing to support the hypothesis that vowels yield more readily to the auditory coding. Her findings suggest that linguistic experience shapes the discrimination of vowels and consonants in a similar way. The identification tasks yield results similar to the discrimination tasks, indicating that identification of speech sounds depends, at least in part, on the number and nature of vowel/consonant categories in the listener's native language.

Clinical Implications of Cross-Language Speech Perception

The administration of a word identification task by a native English speaking audiologist to a non-native English-speaking patient involves dual risks. When the test is administered in English, the perception of the token signal by a patient is mapped onto the existing phonemic category matrices of the patient's native language and, thus, prone to error. When the task is administered in the patient's native language (via recording or monitored live voice, most probably accented), the audiologist is the one performing the identification task when scoring the oral responses of the subject, and is, in his/her turn, prone to error. For example, the target word "dub" ("oak"), when presented to a Russian-speaking patient will likely be repeated as "dup," since the final consonant voiced/voiceless opposition is nonphonemic in Russian (see example below), and will be scored as an erroneous response by an English-speaking audiologist. By the same logic, a Russian speaker is likely to repeat the English word "food" (target word from Northwestern University Auditory Test No. 6, list 4C) as "foot," since the length of the vowel is also nonphonemic in Russian. Moreover, the word identification/recognition test in the patient's native language may not exist.

Recent study by Cokeley and Yager (1993) suggested that for clinical purposes, non-Spanish-speaking experimenters were as accurate when scoring the word recognition responses of the native Spanish-speaking patients as the experimenters with 2-3 years of college-level Spanish courses taken recently. In their study of 10 Spanish-speaking persons', word recognition performance was measured using recordings of four different 50-word lists of bisyllabic Spanish words (Auditec of St. Louis). Their written responses, equaling their "true" performance, were then compared to the results of their pre-recorded oral responses as scored by 15 English-only-speaking judges and 15 English-speaking judges with knowledge of Spanish. The statistical analysis revealed that there was no significant effect of judges' knowledge of Spanish [$F(1,28) = 0.01$, $p > 0.01$]; i.e., word recognition scores were the same when scored by judges with college-level Spanish and judges without a knowledge of Spanish. Yet, a significant main effect of a Spanish speaker (an original subject undergoing the test) and the judges' knowledge of Spanish when compared to the subjects' written responses (i.e., their "true" word recognition performance) was found. In other words, some subjects' oral responses were easier to score for the English-speaking judges than other native Spanish-speaking subjects', and listeners with a knowledge of Spanish approximated the written responses of the subjects closer than the judges with no knowledge of Spanish. The actual differences in scores, however, were reported to be of no clinical significance at one percentage point mean. However, the lack of clinical significance of the judges' knowledge of Spanish might be concealed by a relatively small Spanish-speaking subjects' pool, since written and oral scores ("true" recognition scores and the scores recorded by judges) differed by 10-16 percent for some speakers. A larger sample size and different speakers' characteristics may very well yield clinically significant differences in scores. One can also question the degree of a judges' absence of knowledge of Spanish, since the study was conducted in Texas, where some everyday contact with the Spanish language was inevitable. Furthermore, the findings for other languages, especially tonal ones, may differ due to greater dissimilarity in phonology. Further studies involving larger subject sample sizes and different languages are necessary before generalization to other languages is made. At present, the majority of both clinical science data and results from speech perception studies warrant specific tests interfacing an English-speaking audiologist and non-native English-speaking patients in a way that introduces minimal linguistic constrains (Martin and Hart, 1978; McCullough et al., 1994; Spitzer, 1980).

The Picture-Identification Task offers unique solution to any of the above-mentioned problems.

Picture-Identification Task Paradigm

The Picture-Identification Task originally was developed to estimate the word-recognition performance of non-verbal adults (Wilson and Antablin, 1980). Consonant-vowel nucleus-consonant (CVC) words and three rhyming alternatives that could be illustrated were chosen from the "Teacher's Word Book of 30,000 Words" (Thorndike and Lorge, 1944). The 200 words, which consisted of 175 nouns and 25 action verbs, were distributed among four 50-word lists. Of the test words chosen, 183 had alternative words that rhymed in the final position whereas the remaining 17 had alternative words that rhymed in the initial position. The four lists were assembled to conform to the Lehiste and Peterson (1959) criteria for phonemic balance. Thus, the main criteria used in selection of the target words in the

English PIT were: (a) the test items must be common, familiar words; (b) the test items must be monosyllabic, CVC-structured words to limit the effect of the linguistic/cognitive clues; (c) the test items must be easily pictured; (d) the test items must be phonetically/phonemically balanced; and (e) the test items must have three rhyming alternatives meeting the four criteria listed. The color illustrations of the test words and their rhyming alternatives were made by a commercial artist. Those illustrations were grouped into each of the response plates, where the test word and its three rhyming alternatives were positioned in any of the four quadrants of the response plate. The 200 response plates were bound into the test booklet. Two randomizations of each of four lists were recorded, and each target word was preceded by a carrier phrase, "Show me... ." A 1000-Hz calibration tone corresponding to the peaks of the carrier phrase preceded the randomizations. Normative performance for 16 normal-hearing subjects for the open-set conditions in which the subjects selected the response from one of the four alternatives on the response plate, were established. Psychometric functions for both conditions were generated for the stimulus levels between -2 and 26 dB SL (re: speech recognition threshold (SRT)) and compared to the performance on the Northwestern University Auditory Test No. 6 (NU-6) in open-set (auditory stimulation only) and closed-set (selecting a word from the printed group of four rhyming alternatives) conditions. The results indicated that open-set performance on the Picture-Identification Task test and NU-6 were essentially equivalent and more difficult than the closed-set conditions, and that in closed-set conditions, the identification of words (NU-6, closed-set) was easier than the picture-pointing task. The suggestion was made that additional cognitive processes were required to transform a picture into a lexical unit. This observation should apply to all picture-pointing tasks and will be discussed later in the context of the present work.

Application of the picture-pointing speech tests to the population of speakers of foreign languages came into existence in the late 1970's when Martin and Hart (1978) and Spitzer (1980) described the development of the Spanish SRT tests using bisyllabic stimuli and a picture-pointing response. Martin and Hart (1978) designed the Spanish SRT test that employed easily pictured 12 common Spanish bisyllabic words and tested SRT in Mexican-American children from central Texas. The established SRT of each child was reported to be in good agreement with his/her pure tone average. However, the test, while applicable to the Texan Mexican population, included pictures and words idiosyncratic to the region. The number of words used in the test was too small for effective clinical use.

Spitzer (1980) reported the construction of an alternative Spanish SRT test utilizing 51 familiar bisyllabic target words. A picture of the target word was combined with three distracter pictures on a hard-copy picture plate. The target stimuli were recorded on tape. The scoring sheet included the key to the target word's position in the response plate (one of four quadrants). The experimenter only noted which quadrant was pointed to and compared the response to the keyed picture position on the scoring sheet. Thus, no knowledge of Spanish was required on the clinician's part. The test underwent clinical trials in hospitals in Cleveland, New York City and Newark with patients of Puerto Rican, Cuban, Colombian and Dominican background. The +/- 10 dB SRT-pure-tone average correspondence was reported. Comstock and Martin (1984) reported the development of Spanish word recognition tests (a supra-threshold measurement) to assess the word-recognition ability of Spanish-speaking children based on similar principles. The additional feature of the test was the existence of a separate track on the recording of the test words that presented the target words to the clinician in English as the patient was receiving the same word in Spanish. This feature rendered the test especially easy to monitor and score by a non-Spanish-speaking clinician. The analysis of the performance of 15 adults and 20 kindergarten and grade-school children revealed that the psychometric functions obtained for the four lists comprising the test were similar to the averaged functions of the established discrimination tests in English. The authors commented on the cognitive aspect of any picture-pointing task: in isolation, some of the pictures were not recognizable and response selection, especially at near-threshold levels of hearing, involved an additional task of recognition of the depicted item. This comment will be discussed later in the context of present work.

Picture-pointing word recognition tests as described above were thus established for evaluating non-native

English-speaking patients. Those tests consisted of printed picture-response plates and auditory stimuli recorded on magnetic tape. With the advancements of computer technology and the wide-spread use of computers in clinical practice, the unique application of the cross-language word-recognition tasks using multi-media approach was developed.

McCullough et al. (1992; 1993) described the multi-media approach for evaluating the multi-lingual population. Word identification materials were administered in the computer-controlled multimedia format. In this format, the visual-response portion of the foreign language word identification test was presented on a computer monitor, while the digital auditory-stimulus files were accessed through a computer-audiometer system in the examiner's control room. Once the target word was initiated, a response foil consisting of pictures of the target word and three rhyming alternatives was displayed on the subject's monitor in the test room. The subject responded by pointing to the picture representing the target word. The examiner observed the subject's response and scored the test by noting whether the subject pointed to the correct quadrant of the response foil.

Later, McCullough and Wilson (1995) described the performance of the Spanish-speaking population on the picture-identification task using the multi-media format. The 100 Spanish common vocabulary items were selected to comprise 25 four-word groups. Two 50-word lists were constructed by assigning two words from each four-word group as target words for List 1, and the remaining two items as target words for List 2. The assignment of target words to the test lists ensured balanced distribution of the initial phonemes among the lists. The target words and carrier phrase, "ensename ..." ("show me ..."), spoken by a female speaker of Mexican origin were recorded and edited digitally to establish the auditory-stimulus portion of the materials. An artist's renditions of the vocabulary items, arranged in quadrants on 25 color pictured response foils, were scanned into the computer and appeared on a computer screen as the target word was presented via audio software (Virtual Corporation), routed through an audiometer. Analogous to English Picture-Identification Task experiments (Wilson and Antablin, 1980), two experiments were conducted to establish open-set and closed-set performance of the normal-hearing subjects on the test. In Experiment 1, only the auditory-stimulus portion of the materials was presented in open-set conditions. The normative psychometric function thus obtained was compared to the psychometric function of the Spanish Bisyllable materials obtained by Weisleder and Hodgson (1989). The psychometric functions were fitted with third-order polynomials and the slopes between 20%- and 80%-correct points were calculated. The slopes of the Spanish Picture identification Task and the Spanish Bisyllable materials, recorded by the same speaker, were 3.7% and 3.8%, respectively. These slopes were consistent with the 4.4% slopes for the English Picture-Identification Task (Wilson and Antablin, 1980). This indicated that the Spanish Picture-Identification Task is essentially equivalent to conventional Spanish and English word-recognition materials when presented in an open-set paradigm. In Experiment 2, 10 normal-hearing Spanish-speaking subjects performed the Spanish Picture-Identification Task in the picture-pointing, closed-set paradigm, and the normative psychometric function was obtained at 24, 30, 36, 42 and 48 dB Sound Pressure Level (SPL). The slopes were calculated and found to be similar to the English Picture-Identification Task relationships with the open-set psychometric function slopes. An error analysis was performed to establish the possible origins of the common confusions and the overall difficulty of the test items. The common error sources included phonetic similarity between test items and their alternatives (the desired error source) and differences in familiarity of certain vocabulary items among subjects of different Hispanic cultures. Yet many subjects commented that, although a few of the target words were not the most common word associated with the pictured response in their dialect, they were able to discern that the target word corresponded to the appropriate picture when the alternative pictures were surveyed. The results from Experiment 2 indicated that the Spanish Picture-Identification Task materials were appropriate for administering to adult patients who speak Spanish as the first language for their purpose of establishing word-identification performance. The test could be administered and scored by audiologists who were unfamiliar with Spanish.

Test Items Selection for the Word-Recognition Materials

The initial effort of developing speech materials for the assessment of functional hearing originated for the

English language as early as 1904, when Bryant reported use of spondaic words for establishment of threshold for speech reception. Zubick et al. (1983) summarized the criteria used in the development of English speech audiometric materials by different test authors. Egan, the first author to develop the criteria for a supra-threshold word-discrimination test in 1948, indicated that the major criteria should include monosyllabic structure, equal range of difficulty, equal average difficulty, equal phonemic composition, complete representation of English speech sounds and employment of words in common usage. Composition of a comparable test in any language other than English required modification of the criteria to include the distinctive feature characteristics of the language. For Spanish language tests, Zubick et al. (1983) reported the following criteria: (a) most frequent stress model in Spanish (grave trochaic bisyllables and trisyllabic paraoxytones); (b) word familiarity; (c) homogeneity of basic audibility; (d) equal average difficulty; (e) equal range of difficulty; and (f) list composition. Similar criteria are mentioned by the authors of the analogous word-recognition tests in such languages as

Danish and Welsh (Elberling et al., 1989; Stephens and Jones, 1989).

The developers of the Spanish Picture-Identification Task (McCullough et al., 1995) were faced with the additional constraints in construction of the Spanish test materials. The target words chosen for the test had to be culturally appropriate (i.e., the objects represented by target words and pictures should have been familiar and unambiguous for the Spanish listeners). The technique of screening of potential target words and corresponding pictures for cultural appropriateness by native speakers of Spanish was utilized.

In summary, the validity and reliability of the picture-pointing multiple choice task for assessing supra-threshold word recognition abilities of non-native speakers of English in standard audiological practice has been researched and documented (Martin and Hart, 1978; McCullough et al., 1994; Spitzer, 1980). The criteria of audio/visual word recognition test vocabulary selection were established and discussed in the literature (Zubick et al., 1983; Spitzer, 1980). The unique multi-media test format for the assessment of the word recognition performance of the non-native speakers of English was developed (McCullough et al., 1993). The goals for the present study included development and standardization of the Picture-Identification Task for the Russian-speaking population and incorporation of the Russian Picture-Identification Task into the pool of the existing multi-lingual computer-based word recognition tests.

Chapter III

Methodology

The Russian language was chosen as the next language for the multi-language Picture-Identification Task project due to several factors. First, the recent increase in the Russian-speaking population warranted the development of the appropriate hearing testing tools in this language. Second, utilization of the language of yet another language group, different from the Germanic and Romance languages (English and Spanish, respectively) in many typological aspects, i.e., phonetic inventory and oppositions, length of the words, grammatical structure, etc., promised interesting results and made possible the comparison of the psychometric characteristics of the word identification tasks in various languages.

The goal of the experiment was to establish the normative performance of young normal-hearing native Russian speakers on the developed Russian Picture-Identification Task. The Russian Picture-Identification Task was administered in open-set (auditory stimulation alone) and closed-set (picture-pointing format) conditions.

In the oral, open-set conditions, the percent-correct performance scores yielded specific information about acoustical parameters of the test items, since minimal visual or linguistic cognitive cues were present. Obtaining psychometric functions for the open-set condition permitted comparison of the relative difficulty of separate test items and the effects of syllabic composition on the percent correct performance in Russian and other languages.

In the closed-set, picture-pointing conditions, the subjects performed the task in the form intended for clinical use. The experimenter did not engage in linguistic interaction with subjects following the instructions. Obtaining psychometric functions for the closed-set conditions provided the norms to be used in the clinical decision making and yielded specific information about test composition.

Results of both experimental conditions provided for in-depth analysis and description of the psychoacoustic and visual/cognitive characteristics of the Russian Picture-Identification Task, making it readily available for initial clinical use.

Test Materials

The test items for the Russian Picture-Identification Task consisted of 100 target words comprising 25 groups (foils) of rhyming alternatives. The test items selection rationale and process is described in detail in Appendix A. Based on a series of pilot studies (see Appendix A), it was concluded that 100 selected target words were familiar, commonly used, closely rhyming words that represented the breadth of the Russian phonemes and could be easily and unambiguously pictured.

Test Vocabulary

The 100 selected target words consisted of 86 nouns (83 singular, 3 plural), 16 action verbs (15 in the infinitive, 1 in the imperative), 1 participle and 1 adverb. Of the 25 four-word groupings, 14 consisted of monosyllabic words; the remaining 11 consisted of the bisyllable words. The average length of the target word was four phonemes.

The phonetic composition of the target words was compared to the data from the phoneme frequencies list of the Russian language (Kucera and Monroe, 1968). Table 1 gives the phonemic balance of the 100 potential target words of the Russian Picture-Identification Task in comparison with the Kucera and Monroe data. The data in the table demonstrates that the pattern of the phonemic balance in the Russian Picture-Identification Task generally conformed to the Kucera and Monroe data. The discrepancies in the percentages of the consonant phoneme usage were typically between 1% and 2%, with the exceptions of /k/ and /s/ and /j/. Phonemes /k/ and /s/ were somewhat disproportionally over-represented in the Russian Picture-Identification Task due to the rhyming and linguistic constraints. Phoneme /j/ was reported as more frequently used in the Kucera and Monroe study due to the representation of certain vowel phonemes as having a /j/ component. However, this manner of representation was argued against in other sources (Wade, 1992; Ward, 1970). The variability in the vowels' distribution reflected the variability in possible interpretation of the vowel quality in the unstressed position and additional constraints placed in the word selection by rhyming and linguistic category.

Since the overall conformity of the PIT phonemic composition to the Kucera and Monroe data was present, the Russian Picture-Identification Task was judged representative of the breadth of phonemes in the Russian language and generally followed the pattern of the phonemic distribution in the Russian language.

Table 1

Phonemic Balance of 100 Target Words

Morpheme	# of Phonems in TW	Distribution in TW, %	Distribution in KM, %	Discrepancy TW-KM, %
b	9	2.26	1.46	0.80
v	7	1.76	3.99	-2.23
g	1	0.25	1.30	-1.05
d	9	2.26	2.70	-0.44
ʒ	4	1.00	0.95	0.05
z	2	0.50	1.69	-1.19
k	45	11.30	3.70	7.60
l	19	4.77	4.76	0.01
m	12	3.00	3.12	-0.12
n	19	4.77	6.40	-1.63
p	17	4.27	2.78	1.49
r	22	5.53	4.29	1.24
s	38	9.55	4.96	4.59
t	31	7.79	6.15	1.64
f	1	0.25	1.00	-0.75
h	0	0.00	0.99	-0.99
ts	1	0.25	0.56	-0.31
tʃ	7	1.76	1.63	-0.19
ʃ	8	2.01	1.56	0.45
ʤ	0	0.00	0.00	0.00
j	1	0.25	4.14	-3.89
a	32	8.04		
ə	2	0.50	17.59	0.75
æ	39	9.80		
i	5	1.26		
ɨ	8	2.01	14.53	10.86
o	22	5.53		
ö	5	1.26	4.02	2.77
u	8	2.01	3.50	-1.49
e	23	5.79	2.61	3.18

Note: Table 1 illustrates the phonemic content of the 100 Target Words (TW), the percentage distribution of the target words as compared to Kucera and Monroe data (KM), and the decrepancies between TW and KM (TW-KM).

A complex interplay of the rhyming patterns existed in the foils (see Appendix A for explanation of rhyming nomenclature). Some of the foils consisted only of strict exact initial or final rhyming (foils 1,2,3,4,8 – finally; foils 5,22 – initially). In foils 23 and 25, three words were strictly exactly rhymed, whereas the fourth was in non-strict exact relationship with the others. Foils 6, 10, 11, 12, 18 consisted of a pair of strict exact and a pair of non-strict exact rhyming words. Foils 13, 14, 15, 16, 17, 19, 20 and 21 all included second- and third-order approximations in one or two words in the foil. At the same time, the two approximations within the foil were commonly in non-strict exact rhyming with each other (foils 14, 17, 19, 20). In foil 24, the approximation word was in strict exact rhyming relationship with the rest of the foil finally, while the rest of the foil was initially rhymed. Table 2 illustrates the types of rhyming present in the Russian Picture-Identification Task. In some cases the distinction between orders of approximation was rendered difficult (foils 14, 15, 17, 19, 21).

Table 2

Rhyming and Syllabic Structure of 25 Foils

Foil	Type of Rhyming	Position of Rhyming Elements	Number of Syllables
1	4 strict exact	final	1
2	4 strict exact	final	1
3	4 strict exact	final	1
4	4 strict exact	final	1
5	4 strict exact	initial	1
6	2 strict exact 2 exact	final	2
7	3 strict exact 1 exact	initial	1
8	4 strict exact	final	1
9	4 exact	initial	2
10	2 strict exact 2 exact	final	2
11	2 strict exact 2 exact	initial	2
12	2 strict exact 2 exact	initial	2
13	2 exact 2 second order appr.	final	2
14	2 strict exact 2 second/third order appr.	final	1
15	2 exact 2 first/second order appr.	final	2

(table continues)

Foil	Type of Rhyming	Position of Rhyming Elements	Number of Syllables
16	2 strict exact 1 exact 1 second order app.	initial	2
17	2 exact 2 second/third order app.	initial	1
18	2 strict exact 2 exact	final	1
19	2 strict exact 2 first/second order app.	initial	2
20	2 strict exact 2 second order app.	initial	1
21	2 exact 2 second/third order app.	initial	2
22	4 strict exact	initial	1
23	3 strict exact 1 exact	final	2
24	2 strict exact 1 exact 1 strict exact	final (initial)	1
25	3 strict exact 1 exact	initial	1

The frequency of occurrence of the 100 potential target words in everyday speech is represented on Table 3. All of the target words were found to be familiar to young children. Thirty three percent of the target words were included in the list of the first 1000 most commonly used words in Russian (Amery and Kirilenko, 1983) and 66% were included in the list of 4000 most commonly used words in Russian (Shansky, 1986). Only 24% of the words did not appear in any of the word lists. However, the pilot study indicated that they were rated as "frequently used in everyday speech" by the overwhelming majority of the subjects (see Appendix A for details).

Table 3

Frequency of Occurance of the 100 Target Words:

Target Word	AFI	"1,000 Words"	"4,000 Words"
brosat'			+
baba			+
blisko			+
brat	1.1		
brat'		+	+
beg		+	+
vyt'	1.8		
vnuk			+
glaza		+	+
dvor			+
den'			+
drug			+
dver'		+	+
d'tel'			+
ded		+	+
zhech'	1.2		
d'd'			+
zhena			+
deti		+	+
zver'	1.3		
zhuk		+	
krovat'		+	+
zhaba			+
kiska		+	
zub	1.3		
kosa		+	
kub		+	+
koster	2.2		
kover			+
koshka		+	+

(table continues)

Target word	AFI	"1,000 Words"	"4,000 Words"
klotchok		+	
kofta		+	
kroshka	1.5		
krast'	1.8		
kol	1.2		
kom	1.8		
kot	2.0		
kost'	1.6		
list'a	1.1		
kobra		+	+
lampa	1.8		
korka			+
lozhka	1.5		
lapa			+
len'	1.0		
luk			+
myt'			+
lak			+
mak	1.5		
lech'			+
mama			+
miska			+
maska		+	+
moshka		+	
nozhka	1.2		
marka	1.8		
nos		+	+
maslo			+
nosh'			+
nol'		+	+
osa			+
nozh		+	
pup			+
pet'	1.7		

(table continues)

target word	AFI	"1,000 words"	"4,000 words"
parta		+	+
pasta		+	+
papka			+
papa		+	+
rut'	1.8		
rosa	1.7		
sosat'		+	+
rak			+
sup			+
skakat'			+
shathcok			+
spor		+	+
sest'			
stena			+
sem'			+
set'	1.2		
s'r			+
spina			+
sip'			+
sok			+
sled		+	+
slon		+	+
sol'	2		
sneg			+
son		+	+
s'n		+	+
tetja		+	+
c't			+

(table continues)

Target Word	AFI	"1,000 Words"	"4,000 Words"
sneg			+
son		+	+
s'n		+	+
tetja		+	+
c't			+
tetch'			+
ten'		+	+
tcena			+
shit'			+
shag		+	+

Note: Table 3 lists the information about the frequency of occurence of the target words in everyday speech as judged by subjects of the Pilot Study (AFI), and by the specific literature. Target words present in the books "The first Thousand Words in Russian" (Amery and Kirilenko, 1983) and "4,000 Most Commonly Used Words in Russian" (Shansky, 1986) are indicated by the + sign in a corresponding column. 33% of the target words are listed in "1,000 words..." and 67%, in the "4,000 words...". The data from the Pilot Study is listed for the words that are absent from both books.

Target words are rated on a scale of 1 to 4, 1 being "word is very familiar", commonly used in everyday speech and 4 being "word is unfamiliar", and ascribed the Adult Familiarity Index (AFI). The mean AFI values are listed for the words not present in the familiarity books.

Overall, the words selected for the potential Russian-Picture-Identification Test constitute familiar words that are frequently used in everyday speech. The final 25 foils are included in Appendix B. The 100 target words were divided into two 50-word lists according to the following format: a) each list contained 2 words from each 4-word foil, and b) each list was phonemically balanced, i. e. represented the breadth of Russian phonemes.

Since the combination of initial and final rhyme schemes existed in the 25 groups of target words, the type of rhyming also was taken into account when the division into two 50-word lists was done. The initially rhyming foils were divided so that their final, non-rhyming parts were phonemically balanced between the lists; the division of the finally rhyming foils was similarly phonemically balanced for the initial parts. The 50-word lists (Lists A and B) comprising the Russian Picture identification Task are shown in Table 4.

Table 4

Phonemic Balance of the 50-Word Lists A and B

Phoneme	List A	List B	100 Words
b	5	4	9
v	3	4	7
g	1	0	1
d	6	3	9
ʒ	2	2	4
z	1	1	2
k	23	22	45
l	11	8	19
m	5	7	12
n	10	9	19
p	10	7	17
r	12	10	22
s	18	20	38
t	14	17	31
f	0	1	1
h	0	0	0
ts	0	1	1
tʃ	3	4	7
ʃ	4	4	8
ɣ	0	0	0
j	0	1	1
a	16	16	32
ə	19	20	39
æ	1	1	2
i	3	2	5
ɨ	4	4	8
o	11	11	22
ö	2	3	5
u	4	4	8
e	12	11	23

Note: Table 4 illustrates the phonetic balance of the 50-word lists A and B in comparison with 100-word list.

Recording and Editing Procedures

Two 50-word lists were randomized into a recording list so that words from List A and List B were alternated to ensure equivalent vocal effort across the lists. The recordings were carried out in a double-walled, sound-treated room (Acoustic Systems, Model RC143), with a condenser microphone (AKG Acoustics, Model C460B) and a preamplifier (Symmetrix, Model 202) mounted on a Realistic microphone stand 15 cm away from the speaker. Two volume unit (vu) meters were employed for monitoring the speaker's presentation: one vu meter (Tascam, Model MU-40) was placed in front of the computer operator outside of the sound suite, and the second vu meter (Grason-Stadler, Model 162) was placed in front of the speaker.

The speaker with standard St. Petersburg pronunciation pronounced the carrier phrase "pokazhite gde.." ("show where is...") immediately followed by a target word (carrier phrase co-articulated with the word), then the word alone 4 more times, maintaining the intonation of [the carrier phrase + the word] structure. The last 3 presentations were recorded.

Analog-to-digital recording and subsequent editing were conducted on an analog-to-digital converter (Antex, Model SX-10; 16-bit, 20,000 samples/s) and software loaded on a personal computer (Compaq Desk PRO 386/20C) connected to the recording array.

The waveforms of the recorded words were graphically displayed in the computer monitor screen and the peak-clipped attempts were rejected. The remaining words were evaluated and selected based on the naturalness of intonation and pronunciation. The best presentation then was selected according to following criteria: (a) naturalness of intonation and pronunciation as judged by two independent native Russian speakers, (b) symmetry, uniform displacement and clarity of the waveform. The latter criterion was deemed important for the subsequent editing of the recordings.

Each target presentation was measured at the vu meter in order to provide for the equal sound-pressure levels at the steady state of the stressed vowel of each target word. However, due to difference in the time constant of the vu meter (300 msec) and the relatively short steady state of the Russian vowels (100 msec), the level measurements of the target presentations were made at digital-to-analog (D/A) conversion at 10,000 and 5,000 sampling points per second, thus achieving better correlation between the duration of the areas of the highest level of the stimuli and the time aspect of the vu meter. For the same reasons, the highest points in each target presentation were equated at approximately -2 vu at 20,000 sampling points and at approximately 0 vu at 10,000 sampling points per second. Table 5 lists the measured peaks of each target presentation at 10,000 and 20,000 sampling points per second. The digitized audio files were then recorded onto digital-audio tape (Sony, Model PCM 2500A,B).

Table 5

VU-Meter Measurements of the Target Words at 20,000 and 10,000 Sampling Points D/A Conversion

Target Word	VU at 20,000 points	VU at 10,000 points
brosat'	-3	0
baba	-1	0
blisko	-1.75	0
brat	-2	0
brat'	-2	0
beg	-2.25	0.5
vyt'	-2	0
vnuk	-2	0
glaza	-2	0
dvor	-2	0
den'	-2.5	0
drug	-2	0
dver'	-2	0
d'tel'	-2	-0.5
ded	-2.5	0.25
zhech'	-2	0
d'd'	-2	-0.75
zhena	-1	-1
deti	-2	0
zver'	-2	0.25
zhuk	-3	-1
krovat'	-2	0
zhaba	-2	0
kiska	-3	0
zub	-3	-0.5
kosa	-4	0
kub	-2.75	0
koster	-3	0
kover	-2	0
koshka	-3.5	0
klotchok	-2.5	0
kofta	-3	0
kroshka	-3	0
krast'	-2	0
kran	-2	0
kol	-2	0
kom	-3	0
kot	-2.5	0

(table continues)

Target Word	VU at 20,000 points	VU at 10,000 points
kost'	-3	0
list'a	-2.75	0
kobra	-3.5	0
lampa	-2	0
korka	-3	0
lozhka	-2.5	0
lapa	-2	0
len'	-1.5	0
luk	-2.5	0
myt'	-1.5	0
lak	-2	-0.25
mak	-2	0
lech'	-3	-0.25
mama	-2	0
miska	-4	-2.75
maska	-2.5	0
moshka	-2.5	0
nozhka	-1	0
marka	-2	0
nos	-1	0
maslo	-2.5	0
nosh'	-2	0
nol'	-2	0
osa	-3	-1.75
nozh	-2.5	0
pup	-3.5	0
letch'	-3	0
pen'	-3	0
pet'	-2.75	0
parta	-2	0
pasta	-3	0
papka	-2	0
papa	-2	0
rut'	-2	0
rosa	-3	-1.25
sosat'	-3	0
rak	-3	-1
sup	-4	0
skakat'	-2	0
shathok	-4	0
spor	-2	0
sest'	-3.5	0

(table continues)

Target Word	VU at 20,000 points	VU at 10,000 points
stena	-2	-0.75
sem'	-3	0
set'	-3	0
s'r	-3	0
spina	-2.75	0
sip'	-3	0
sok	-3	0
sled	-2.5	0
slon	-2	0
sol'	-2.5	0
sneg	-2	-0.75
son	-2.5	0
s'n	-3	0
tetja	-3	0
c't	-3	0
tetch'	-2	0
ten'	-2	0
tcena	-0.5	0
shit'	-2.5	0
shag	-2.5	0

Subjects

Subjects for this study were 21 young normal-hearing Russian-speaking persons. All of the subjects were of Central Russian origin, permanently residing in the United States for no longer than six years (17 subjects) or visiting the country for a period of one year or less (three subjects). One male subject resided in the United States for 15 years since the age of 13, but used Russian as his primary language of communication both at home and at work. Five males and five females (ages 11 – 33, mean age = 24.8 years) were chosen as subjects for the oral, open-set conditions. Eight females and seven males (ages 20 – 34, mean age = 29.1 years), four of whom participated in the open-set experiment, served as subjects for the picture-pointing, closed-set conditions. The time elapsed between open-set and closed-set condition experiments (18 months) precluded any learning effects, thus the use of the same subjects was permissible. Additionally, closed-set response paradigm minimized learning effects. The demographic information summary for the subjects of the open-set and closed-set conditions is presented in Table 6.

All subjects demonstrated normal hearing sensitivity with thresholds at $\leq$15 dB HL as measured at octave intervals from 250 to 8000 Hertz (Hz) in the test ear. Normal results of the otoscopic examination were demonstrated by all subjects. No history of ear pathology was reported by any subject.

Table 6

Subjects of the Study: Age, Gender,

Time Spent in US

Subject	Age	Gender	Months in US
Pilot Study: Target Word Familiarity			
EP	5.9	M	12
KB	7.0	F	7
EB	9.0	F	7
LK	22.0	M	18
MM	24.0	F	24
LL	29.0	M	7
DR	28.0	M	60
SD	32.0	F	7
IN	26.0	F	18
SB	30.0	M	12
KS	36.0	M	192
TB	31.0	F	12
OF	53.0	M	60
VY	53.0	F	60
MF	68.0	M	7
LN	59.0	F	18
GM	64.0	M	18
BM	80.0	F	60
Normative Open-Set			
SF	30.0	M	24
TR	29.0	M	24
RT	27.0	M	168
OT	29.0	M	72
BA	25.0	M	60
DF	22.0	F	36
OP	17.0	F	1
BS	11.0	F	5
KY	33.0	F	5
LY	27.0	F	36

(table continues)

	Normative Closed-Set		
MM	21.0	F	48
IK	20.0	M	36
PT	30.0	M	36
BA	26.0	M	72
MO	29.0	M	204
JB	30.0	M	48
IS	34.0	F	47
GM	30.0	M	84
IN	26.0	F	84
OP	32.0	F	60
AR	26.0	F	60
JI	32.0	F	12
TB	34.0	F	36
SB	32.0	M	36
VV	34.0	F	36

Procedures

Digitized recordings of the test lists A and B were presented to each subject individually under monaural listening conditions through an audiometer (Grason-Stadler, Model 16).

Open-Set Conditions

For the open-set word recognition conditions, each subject listened to three randomizations of the two 50-word lists presented from 20 dB SPL to 56 dB SPL in 6 dB-steps. During the one-hour test session, each subject listened to seven presentations of the six word lists, with the same list presented initially (20 dB SPL) and finally (56 dB SPL), thus minimizing memorization of a twice-presented list. Test ear and word-list randomizations were counterbalanced across subjects. According to the standard picture-pointing word-identification format (McCullough et al., 1993), each target word was preceded by a carrier phrase: "pokazhite gde.." ("show me where..."). Subjects were instructed to ignore the carrier phrase and write down the target word on an answer form. Following the session, the responses were scored by the Russian-speaking experimenter.

Closed-Set Conditions

For the closed-set word-identification conditions, the artist-designed picture plates were combined into a four-per-foil arrangement. Each subject was seated in the sound-treated test room facing a computer monitor screen, while the experimenter sat in the audiology control room. The experimenter pointed and clicked on the target word, printed in English on the experimenter's computer screen, and the corresponding picture response foil appeared on the patient's screen. Simultaneously, the corresponding auditory stimulus was delivered to the test ear at the appropriate sensation level. The following instructions were given to each subject in Russian: "On the computer screen you will see four pictures corresponding to four similarly sounding words. You will hear the voice asking you to show the picture corresponding to a particular word. Point to the picture that, in your opinion, best depicts the word you have heard. If you are not sure, guess." The experimenter observed the pointing responses through the control-room window and scored the responses by circling the pointed word on the scoring sheet.

The pictures in each foil were assigned to any of the four quadrants in such a manner that for any order of presentation of any of the quarter-lists (one run through the foils) the target word positions on a screen were randomized. That technique eliminated possible response bias for the pointing task. Target word lists A and B, each containing 50 words, were arbitrarily divided into half-lists A1, A2, B1 and B2 to accommodate the experimental paradigm. Therefore, each 4-picture response foil contained two target words for each list, and presentation of one list consisted of going through all 25 screens twice. The lists were presented at seven ascending sound pressure levels of 14, 20, 26, 32, 38, 44 and 50 dB SPL. List order and test ear were counterbalanced across subjects: odd-numbered subjects received stimulation in the left ear starting with list A, even-numbered subjects received stimulation in the right ear starting with list B. In order to minimize learning effects, a different order of calling up the picture foils was utilized from level to level.

Data Analysis

Mean percent correct performance and standard deviations for the Russian Picture-Identification Task in the open-set and closed-set conditions were calculated. Psychometric functions, fitted with third-order polynomials, were obtained for both conditions, and slopes of the linear portions between 30 and 80 percent correct points were calculated and are included in Appendix C. The performance of the normal-hearing subjects on the Russian Picture-Identification Task was compared to the performances obtained from native English and Spanish speakers on the similar tasks in these languages (Northwestern University Auditory Test No. 6 and Spanish Word Identification Task, respectively). Analysis of the patterns of errors was performed for both open-set and closed-set experimental conditions.

Chapter IV

Results

The purpose of this research was to establish normative performance on a Russian audio/visual word recognition test. Twenty one subjects with normal-hearing participated in the study. The Russian Picture-Identification Task was presented to 10 subjects in the open-set, oral response only conditions, and to 15 subjects in the closed-set picture-pointing format. Mean percent correct performance on List A and B and on the full test (Lists A and B combined) was calculated for both conditions. Psychometric functions (percent correct performance as a function of presentation level) also were calculated using the mean data for both open-set and closed-set conditions.

Open-Set Conditions

Percent correct performance for the 10 subjects on Lists A and B in oral, open-set conditions is given in Table 7. Mean percent correct performance and standard deviations were calculated for each list and also are included in the table. For List A, mean percent correct performance ranged from 2.0 percent at 20 dB SPL to 98.8 percent correct at 56 dB SPL. Standard deviations ranged from 1.7 at 56 dB SPL to a maximum of 24.5 at 38 dB SPL. For List B, mean percent correct performance ranged from 2.0 percent at 20 dB SPL to 98.4 percent at 56 dB SPL. Standard deviations were 1.6 at 56 dB SPL to a maximum of 23.5 at 32 dB SPL.

Statistical analysis of the subjects' performance on lists A and B was performed, and the performance was found essentially equivalent between Lists A and B. Therefore, the data from lists A and B were combined and also are presented in Table 7. Mean percent correct performance of the subjects ranged from 2 percent correct at 20 dB SPL to 98.4 percent correct at 56 dB SPL. Standard deviations ranged from 2.6 percent at 20 dB SPL to a maximum of 18.9 percent at 32 dB SPL.

The mean percent correct performance for the open-set conditions was plotted as a function of the sound pressure level of the stimulus. The resultant psychometric function is shown in Figure 1. The function was essentially linear from 20 to 44 dB SPL with a slope of 3.9%/dB. Performance became asymptotic at presentation levels of 50 and 56 dB SPL, where ceiling effects were noted.

Table 7

Individual Subjects' Percent Correct Performance

for the Open-Set Conditions

Subject	Presentation Level (dB SPL) 20	26	32	38	44	50	56
				List A			
SF	4		62		92		98
TR		28		80		96	
RT	6		44		92		100
OT		26		86		94	
BA	0		44		96		100
DF		0		40		90	
OP	0		28		82		100
BS		2		30		94	
KY	0		38		72		96
LY		22		52		88	
Mean	2	15.6	43.2	57.6	86.8	92.4	98.8
SD	2.8	13.5	12.3	24.5	9.7	3.2	1.7
				List B			
SF		40		76		96	
TR	0		62		92		98
PT		36		70		92	
OT	6		62		92		100
BA		18		70		96	
DF	0		16		66		100
OP		6		58		92	
BS	0		14		82		96
KY		18		48		90	
LY	4		34		76		98
Mean	2.0	23.6	37.6	64.4	81.8	93.2	98.4
SD	2.8	14.1	23.5	11.2	11.0	2.6	1.6

(table continues)

Subject	Presentation Level (dB SPL) 20	26	32	38	44	50	56
				List A and B Combined			
SF	4	40	62	76	92	96	98
TR	0	28	62	80	92	96	98
RT	6	36	44	70	92	92	100
OT	6	26	62	86	92	94	100
BA	0	18	44	70	96	96	100
DF	0	0	16	40	66	90	100
OP	0	6	28	58	82	92	100
BS	0	2	14	30	82	94	96
KY	0	18	38	48	72	90	96
LY	4	22	34	52	76	88	98
Mean	2.0	19.6	40.4	61.0	84.2	92.8	98.4
SD	2.6	13.7	18.0	18.4	10.2	2.9	1.6

Closed-Set Conditions

Table 8 represents the performance of 15 subjects on list A and B in the closed-set, picture-pointing conditions. For List A, mean percent correct performance ranged from 30% at 14 dB SPL to 100% at 50 dB SPL. Standard deviations ranged from 0.0% at 50 dB SPL to a maximum of 20.6% at 32 dB SPL. For List B, mean percent correct performance ranged from 28.3% at 14 dB SPL to 99.8% at 50 dB SPL. Standard deviations ranged from a minimum of 0.7% at 50 dB SPL to a maximum of 19.1% at 26 dB SPL.

Psychometric functions for Lists A and B were essentially equivalent, demonstrating close correspondence in subjects' performance on lists A and B. Statistical analysis had confirmed this effect. Therefore, lists A and B were combined for further analysis. Table 8 also summarizes the combined performance on both lists and reports mean percent correct performance and standard deviations calculated for each level. Mean performance of the subjects ranged from 29.1 percent correct at 14 dB SPL, which was slightly above chance for the task (25%), to 99.9 percent correct at 50 dB SPL, where all but one subject achieved a perfect score. Standard deviations ranged from 0.0 at 50 dB

SPL to 14.9 at 26 dB SPL.

The mean percent correct performance for the Russian Picture-Identification Task in closed-set conditions is plotted in Figure 1 (open circles) as a function of presentation level. The psychometric function thus obtained was fitted with a third-degree polynomial to calculate the slope of the function (see Appendix C). The slope of the psychometric function calculated on the linear portion between 30 and 80 percent correct points was 2.3%/dB.

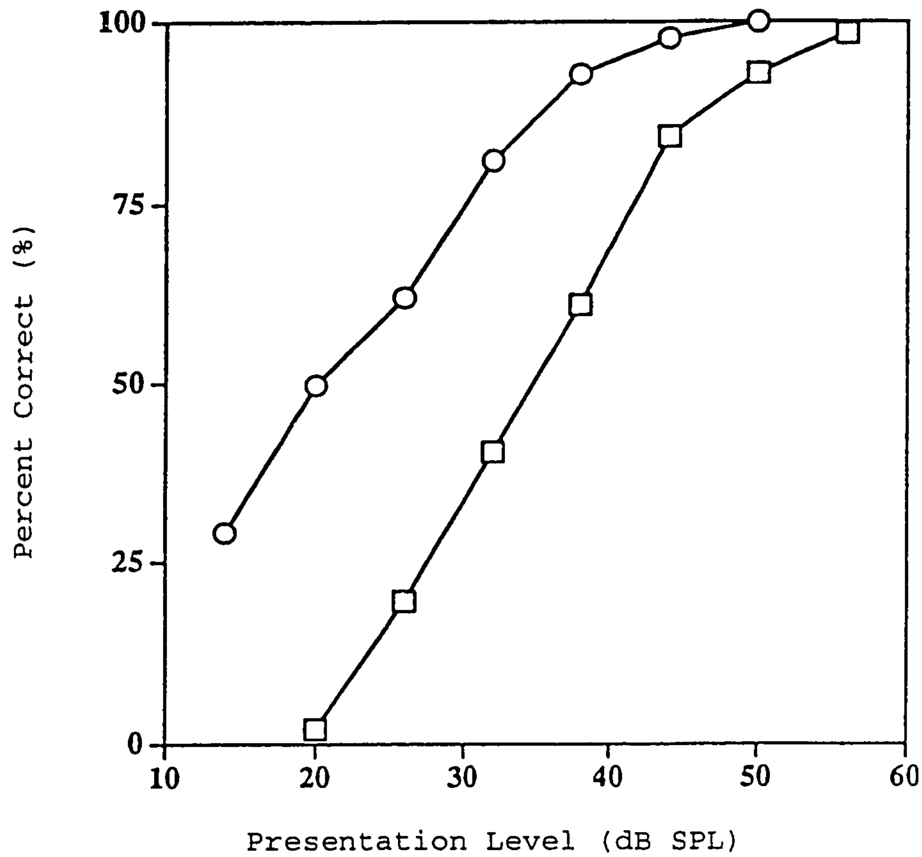


Figure 1. Psychometric functions for the Russian Picture-Identification Task in the open-set (open squares) and closed-set (open circles) conditions.

Table 8

Individual Subjects' Percent Correct Performance

for the Closed-Set Conditions

Subject	Presentation Level (dB SPL)						
	14	20	26	32	38	44	50
				List A			
MM		22		36		88	
IK	22		52		96		100
PT		44		92		98	
BA	38		66		96		100
MO		58		94		100	
JB	44		56		88		100
IS		56		90		98	
GM	26		74		98		100
IN		70		96		100	
OP	22		52		94		100
AR		44		84		100	
JI	32		62		96		100
TB		58		94		100	
SB	26		64		94		100
VV		24		68		96	
Mean	30.0	47.0	60.9	81.8	94.6	97.5	100
SD	8.4	17	8.7	20.6	3.2	4.1	0
				List B			
MM	22		22		62		98
IK		48		72		96	
PT	18		74		98		100
BA		52		78		100	
MO	40		78		92		100
JB		56		80		98	
IS	42		76		94		100
GM		60		88		98	
IN	32		74		100		100
OP		42		80		100	
AR	22		54		98		100
JI		54		80		98	

(table continues)

	Presentation Level (dB SPL)						
Subject	14	20	26	32	38	44	50
TB	30		32		96		100
SB		58		82		96	
VV	20		54		88		100
Mean	30.0	47.0	60.9	81.8	94.6	97.5	100
SD	8.4	17	8.7	20.6	3.2	4.1	0
	List A and B combined						
MM	22	22	22	36	62	88	98
IK	22	48	52	72	96	96	100
PT	18	44	74	92	98	98	100
BA	38	52	66	78	96	100	100
MO	40	58	78	94	92	100	100
JB	44	56	56	80	88	98	100
IS	42	56	76	90	94	98	100
GM	26	60	74	88	98	98	100
IN	32	70	74	96	100	100	100
OP	22	42	52	80	94	100	100
AR	22	44	54	84	98	100	100
JI	32	54	62	80	96	98	100
TB	30	58	72	94	96	100	100
SB	26	58	64	82	94	96	100
VV	10	24	54	68	88	96	100
Mean	29.1	49.7	62	80.9	92.7	97.7	99.9
SD	13.0	14.6	14.9	9.20	3.10	0.50	0.00

Chapter V

Discussion

The goal of the present study was to describe normative performance on the newly developed Russian auditory/visual picture identification materials. Normative performance was evaluated for two presentation conditions: open set (auditory stimulus, oral-response mode) and closed set (auditory stimulus picture-pointing response mode). The open set condition yielded information about acoustic characteristics of the test items. The closed-set condition in the auditory/visual format was utilized to establish the normative performance of the Russian-speaking population on the picture-pointing word-identification task in its clinical format. In this format, an English-speaking audiologist would be able to reliably evaluate the supra-threshold word recognition performance of the Russian-speaking population (cf. McCullough et al., 1993). The closed-set condition yielded information pertaining to the psychoacoustic and cognitive/visual characteristics of the test.

One hundred target words were assembled into two test lists (Lists A and B) to provide the clinician with two interchangeable test lists. The words were assigned to a list such that equal representation of Russian phonemes existed between the lists. A comparison of mean percent-correct performance of subjects on Lists A and B for open-set and closed-set conditions was made and will be discussed.

Additionally, subjects' performance on the Russian materials was compared with previous data using English and Spanish materials in order to define common characteristics of multi-lingual word recognition performance. Finally, a detailed error analysis was performed for the closed-set data to establish the relationship between confusion patterns and the rhyming and syllabic properties of the materials.

Comparison of Test Lists A and B

Repeated measures analysis of variance (ANOVA) was performed to evaluate the difference of subjects' performance on lists A and B for the open-set and closed-set conditions. For the open-set conditions, ANOVA yielded $F_{1,68}=3.67, p>0.05$, demonstrating no significant difference in ten experimental subjects' performance for lists A and B. For the closed-set conditions, repeated measures ANOVA yielded $\underline{F}_{1,109}=2.68, \underline{p}>0.05$, demonstrating no significant difference in 15 experimental subjects' performance for lists A and B. The results of the ANOVA indicated essential similarity between the lists. Lists A and B were therefore combined together for further analysis.

Comparison of Russian, Spanish and English Word Identification Materials

Figure 2 illustrates the psychometric functions for NU-6 (panel a) and the English (panel b), Spanish (panel c) and Russian (panel d) Picture-Identification Tasks. The RPIT psychometric function is re-plotted from Figure 1. Mean percent-correct performance data for the Spanish and English Picture-Identification Tasks and NU-6 in open-set conditions were obtained from McCullough et al., 1995 and Wilson and Antablin, 1980. Individual data points for each function were fitted with third-degree polynomials to obtain the slopes of the functions.

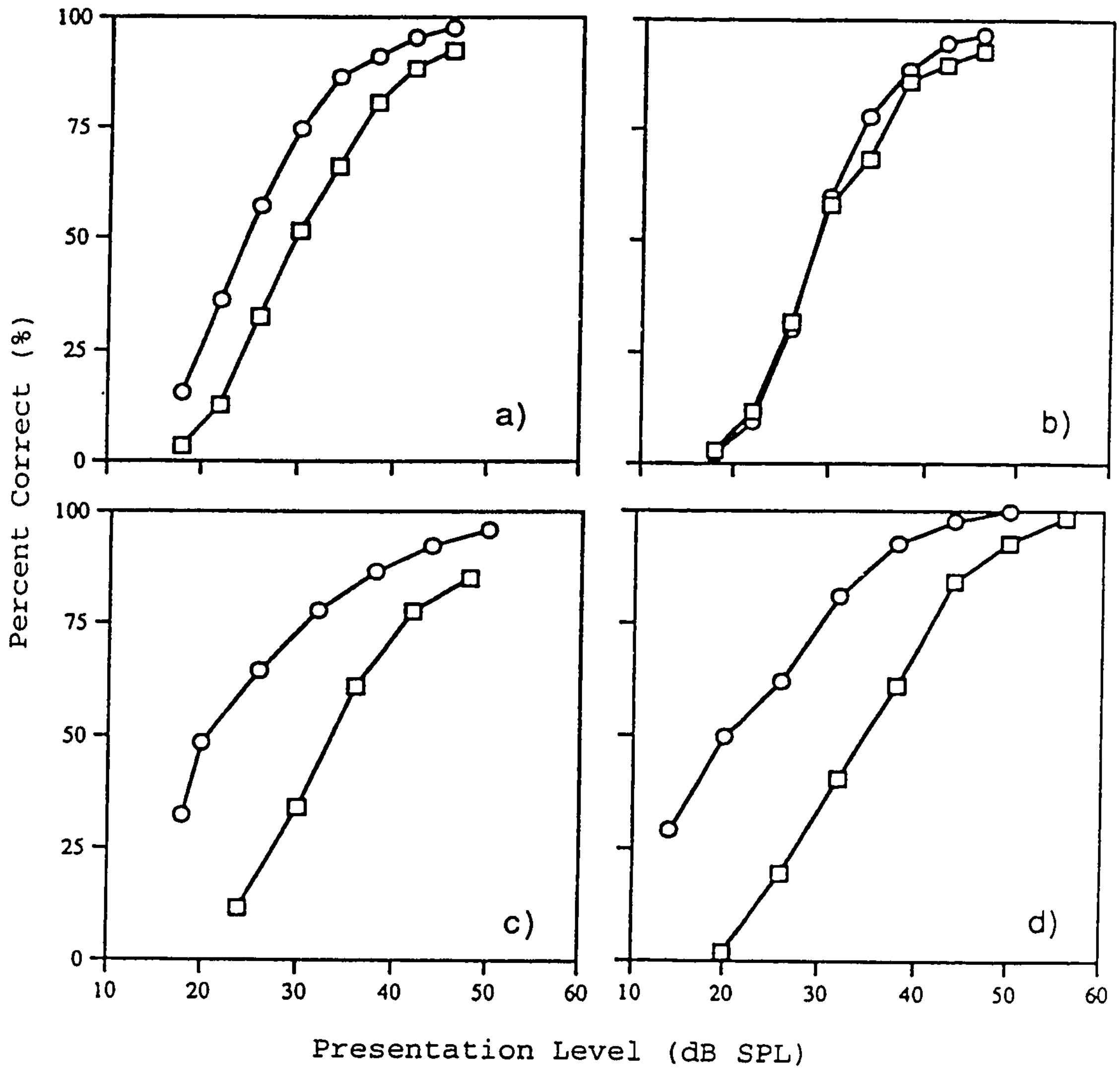


Figure 2. Open-set (open squares) and closed-set (open circles) psychometric functions for NU-6 (panel a), the English (panel b), Spanish (panel c) and Russian (panel d) Picture-Identification Tasks.

For the open-set conditions (open squares), all four functions were consistent in overall shape, rate of growth and performance plateau. The slope of the RPIT psychometric function of 3.9%/dB on the linear portion was comparable with 3.7%/dB for SPIT, 4.3 %/dB for English Picture-Identification Task and 4.0%/dB NU-6 test (McCullough et al., 1995; Wilson and Antablin, 1980). The third-order polynomial equations generated to represent the psychometric functions of each test are listed in Appendix C.

In closed-set conditions, the slope of the RPIT psychometric function was 2.3%/dB and was comparable to the 1.8%/dB for the Spanish-Picture-Identification Task (McCullough and Wilson, 1995). However, both the English Picture-Identification Task and NU-6 in the closed-set conditions exhibited steeper slopes, similar to the open-set conditions (5.2%/dB and 4.5%/dB, respectively). Higher percent correct scores at lower presentation levels (14, 18, 20, 22, 24 dB SPL) were achieved for Spanish and Russian than for English word identification materials, thus resulting in steeper slopes for the latter.

Psychometric functions for Spanish and Russian Picture-Identification tasks exhibited similar displacements between the open-set and closed-set experimental conditions. For both tests, the functions for the closed-set materials were displaced by approximately 15 dB at the 30 percent correct point and by approximately 10 dB at 80 percent correct point. Smaller displacement of approximately 10 dB for all levels of performance was reported for NU-6 open-set and closed-set conditions (Wilson and Antablin, 1980). Minimal displacement was observed for English (Wilson and Antablin, 1980), probably because the experimental paradigm did not impose a forced-choice response mode.

The differences in slopes and displacement patterns between Russian, Spanish, and English materials were hypothesized to result from differences in syllable length and degree of acoustic phonetic similarity between test items for tests in different languages (Grace, 1992; Wilson and Antablin, 1982). English word identification materials consisted of monosyllabic and minimally varied alternatives (Wilson and Antablin, 1980). The target word and its alternatives constituted minimal pairs, i.e., they differed by a single phoneme. Both Spanish and Russian test items were longer than the English (bisyllables for Spanish and combination of monosyllables and bisyllables in Russian) and included items more phonetically dissimilar than minimal pairs. Previous research has shown that the length of a word directly correlates with the number of contextual phonetic information available to a listener (Hirsh et. al., 1952) hence, Spanish bisyllabic materials were easier to recognize in open-set conditions. In the forced-choice closed-set conditions, minimally varied foils provided for less phonetic differentiation between the items, making the identification task harder for the English than for Russian and Spanish picture identification materials.

The experiment conducted demonstrated the overall consistency between Russian Picture-Identification Task psychometric functions in open-set conditions and those reported for the Spanish Picture-Identification Task (Wilson & McCullough, 1982; McCullough and Wilson, 1995) and the English Picture-Identification Task (Wilson and Antablin, 1980).

Since a combination of monosyllables and bisyllables and different rhyming patterns (see Appendix A) existed in the Russian Picture-Identification Task, a detailed error analysis was undertaken to evaluate the effects of the syllabic composition and the degree of phonetic similarity on the performance of normal-hearing subjects.

Error Analysis

For closed-set conditions, the analysis of performance patterns of individual foils was undertaken to establish the relationship between these patterns and the rhyming and syllabic properties of the foils. It was hypothesized that the number of syllables in the words comprising a foil, rhyming patterns within a foil, and the degree of phonetic similarity between the items in a foil would be reflected in the number of confusions made by subjects at each presentation level (Hirsh et al., 1952).

For the open-set condition, the oral responses of the subjects were recorded by the Russian-speaking experimenter and the total number of errors for each target word was computed as a function of presentation level. The results of this error analysis are presented in Table 9.

For the closed-set condition, the number of times each target word in a four-word response was substituted for another member of the foil was recorded during the experiment and later computed as a function of presentation level. The results of this error analysis are presented in Table 10. Additionally, the overall number of confusion errors per foil using data from seven presentation levels (20 to 56 dB SPL) was computed to be used in the error analysis.

Table 9

The Number of Errors for Each of the Russian Target Words in Open-Set Test Condition

	Number of Errors at Presentation Level							
Word	20dB	26dB	32dB	38dB	44dB	50dB	56dB	Total
brosat'	5	5	4	2	0	0	0	16
baba	5	2	3	0	0	0	0	10
blisko	5	4	2	1	1	0	0	13
brat	5	5	3	3	1	1	0	18
brat'	5	4	4	2	0	1	0	16
beg	5	5	4	3	3	0	0	20
vyt'	5	3	4	3	0	0	0	15
vnuk	5	4	3	0	1	0	0	13
glaza	5	3	2	1	0	0	0	11
dvor	5	5	4	1	0	0	0	15
den'	5	5	5	1	0	0	0	16
drug	5	4	3	0	0	0	0	12
dver'	5	4	3	1	0	0	0	13
d'tel'	5	4	3	1	0	0	0	13
ded	5	4	4	2	1	0	0	16
zhech'	5	4	3	0	0	0	0	12
d'd'	5	5	3	1	0	1	0	15
zhena	5	4	3	0	0	0	0	12
deti	5	5	3	3	0	0	0	16
zver'	5	5	5	4	2	0	0	21
zhuk	5	5	3	1	0	0	0	14
krovat'	5	2	3	0	0	0	0	10
zhaba	5	3	1	0	0	0	0	9
kiska	5	4	5	1	1	0	0	16
zub	5	4	3	0	0	0	0	12
kosa	5	5	3	0	0	0	0	13
kub	5	5	5	3	1	0	0	19
koster	5	4	3	0	1	0	0	13
kover	5	4	2	1	0	0	0	12
koshka	5	3	3	0	0	0	0	11
klotchok	5	4	3	0	0	0	0	12
kofta	5	5	4	1	0	0	0	15
kroshka	5	5	3	3	1	1	0	18
krast'	5	5	1	1	0	0	0	17
kran	5	5	1	0	0	0	0	11
kol	5	5	5	4	3	1	1	24

(table continues)

Word	Number of Errors at Presentation Level 20dB	26dB	32dB	38dB	44dB	50dB	56dB	Total
kom	5	5	1	0	0	1	0	12
kot	6	2	2	2	0	0	1	13
kost'	3	2	2	1	1	0	0	9
list'a	4	2	1	1	0	0	0	8
kobra	4	0	2	1	0	0	0	7
lampa	6	3	4	1	0	0	0	14
korka	5	0	5	3	1	0	0	14
lozhka	4	3	0	0	0	0	0	7
lapa	4	5	2	1	0	0	0	12
len'	8	6	4	1	1	0	0	20
luk	3	3	2	1	0	0	0	9
myt'	8	2	2	1	1	0	0	14
lak	2	3	3	0	0	0	0	8
mak	5	1	1	0	0	0	0	7
lech'	5	4	7	1	1	0	0	18
mama	5	2	2	0	0	0	0	9
miska	4	2	1	1	0	0	0	8
maska	4	3	4	0	1	0	0	12
moshka	7	3	5	0	0	0	0	15
nozhka	7	2	3	0	0	0	0	12
marka	3	2	4	3	1	0	0	13
nos	5	4	5	2	2	1	1	20
maslo	6	8	4	1	0	1	0	20
nosh'	7	6	6	5	1	1	0	26
nol'	3	3	3	2	0	0	0	11
osa	5	1	2	0	0	0	0	8
nozh	2	5	0	1	0	0	0	8
pup	7	5	5	2	1	0	0	20
petch'	5	4	7	1	1	0	0	18
pen'	7	4	5	3	3	0	0	22
pet'	6	6	3	1	1	0	0	17
parta	5	3	2	2	0	0	0	12
pasta	2	3	3	1	0	0	0	9
palka	5	2	2	0	1	0	0	10
papa	6	3	2	2	0	0	0	13
rut'	4	5	0	0	1	0	0	10
rosa	6	5	0	2	0	0	0	13
sosat'	7	4	1	2	1	0	0	15
rak	2	2	0	0	0	0	1	5
sup	6	4	4	2	0	0	0	16
skakat'	6	5	3	0	0	0	0	14

(table continues)

Word	Number of Errors at Presentation Level							Total
	20dB	26dB	32dB	38dB	44dB	50dB	56dB	
shatchok	5	4	3	2	0	0	0	14
spor	5	5	5	3	3	3	0	24
sest'	5	5	5	3	0	0	0	18
stena	4	5	2	0	0	0	0	11
sem'	5	5	5	2	4	4	2	27
set'	5	5	5	5	2	0	0	22
syr	5	4	2	0	0	0	0	11
spina	4	4	2	2	0	1	0	13
sip'	5	5	4	0	0	0	0	14
sok	5	4	3	0	0	0	0	12
sled	5	5	5	4	2	1	0	22
slon	5	5	4	3	0	0	0	17
sol'	5	4	4	1	0	1	0	15
sneg	5	5	3	0	0	0	0	13
son	5	5	3	1	1	0	0	15
syn	5	5	4	1	1	0	0	16
tetja	5	4	4	2	0	0	0	15
syt	5	5	5	3	1	0	0	19
tetch'	5	5	4	2	0	0	0	16
ten'	5	5	3	2	0	0	0	15
tcena	5	5	4	2	1	0	0	17
shit'	5	5	3	1	1	0	0	15
shag	5	5	5	2	1	0	1	19

Table 10

The Number of Errors for Each of the Russian Target Words in Closed-Set Test Condition

	Number of Errors at Presentation Level							
Word	20dB	26dB	32dB	38dB	44dB	50dB	56dB	Total
brosat'	2	3	3	1	1	0	0	10
baba	7	1	1	0	0	0	0	9
blisko	7	3	3	1	0	0	0	14
brat	6	6	4	2	0	0	0	18
brat'	7	4	4	2	1	0	0	18
beg	5	2	5	1	1	0	0	14
vyt'	6	5	1	2	0	0	0	14
vnuk	3	5	4	2	1	0	0	15
glaza	5	3	0	1	0	0	0	9
dvor	6	2	5	4	1	0	0	18
den'	6	7	4	3	0	0	0	20
drug	7	5	5	0	2	1	0	20
dver'	6	6	4	3	1	0	0	20
d'tel'	4	1	0	1	2	0	0	8
ded	4	5	4	2	1	0	0	16
zhech'	5	4	1	0	0	0	0	10
d'd'	6	6	2	2	1	1	0	19
zhena	4	2	0	0	0	0	0	6
deti	4	2	3	0	0	0	0	9
zver'	8	6	6	5	3	1	0	29
zhuk	4	4	2	1	0	0	0	11
krovat'	3	2	2	0	0	0	0	7
zhaba	6	2	0	2	0	0	0	10
kiska	7	4	3	2	0	0	0	18
zub	1	6	4	2	1	0	0	14
kosa	5	3	4	0	0	0	0	12
kub	6	2	5	2	0	1	0	16
koster	3	2	2	0	0	0	0	7
kover	3	3	0	0	0	0	0	6
koshka	4	0	1	0	0	0	0	5
klotchok	6	5	2	1	0	1	0	15
kofta	6	0	4	2	1	0	0	13
kroshka	5	5	3	2	0	0	0	15
krast'	8	3	6	1	2	0	0	20
kran	6	3	2	0	1	0	0	12
kol	5	1	5	2	2	0	0	15

(table continues)

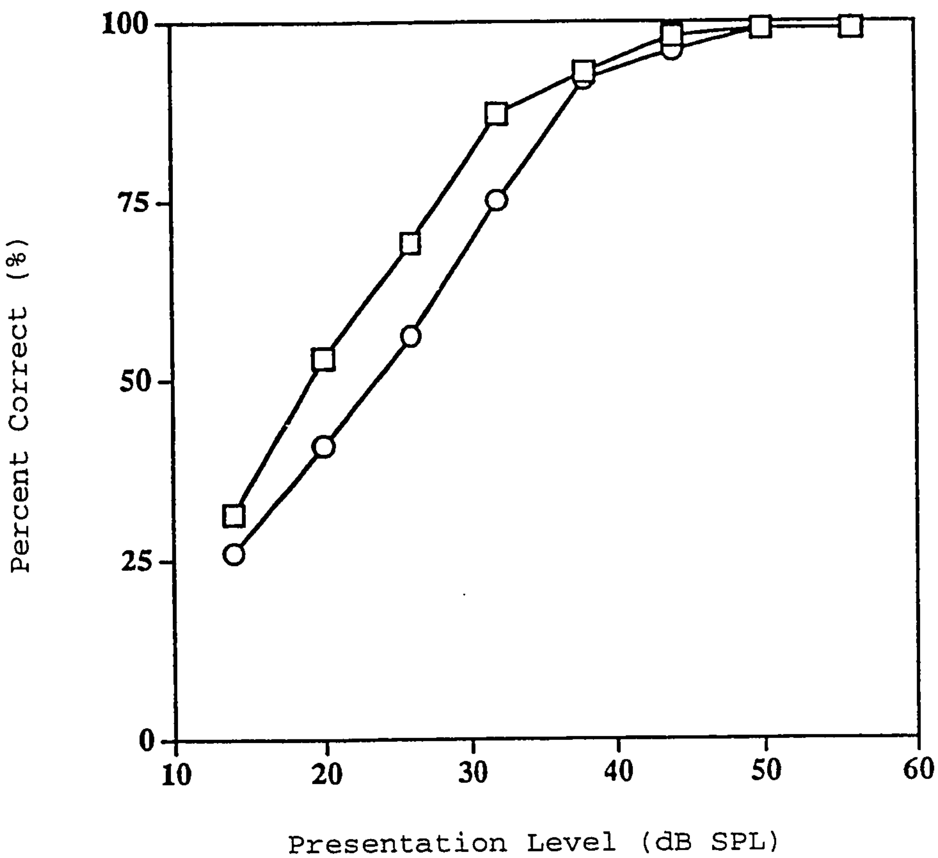
Word	Number of Errors at Presentation Level 20dB	26dB	32dB	38dB	44dB	50dB	56dB	Total
kom	5	5	1	0	0	1	0	12
kot	6	2	2	2	0	0	1	13
kost'	3	2	2	1	1	0	0	9
list'a	4	2	1	1	0	0	0	8
kobra	4	0	2	1	0	0	0	7
lampa	6	3	4	1	0	0	0	14
korka	5	0	5	3	1	0	0	14
lozhka	4	3	0	0	0	0	0	7
lapa	4	5	2	1	0	0	0	12
len'	8	6	4	1	1	0	0	20
luk	3	3	2	1	0	0	0	9
myt'	8	2	2	1	1	0	0	14
lak	2	3	3	0	0	0	0	8
mak	5	1	1	0	0	0	0	7
lech'	5	4	7	1	1	0	0	18
mama	5	2	2	0	0	0	0	9
miska	4	2	1	1	0	0	0	8
maska	4	3	4	0	1	0	0	12
moshka	7	3	5	0	0	0	0	15
nozhka	7	2	3	0	0	0	0	12
marka	3	2	4	3	1	0	0	13
nos	5	4	5	2	2	1	1	20
maslo	6	8	4	1	0	1	0	20
nosh'	7	6	6	5	1	1	0	26
nol'	3	3	3	2	0	0	0	11
osa	5	1	2	0	0	0	0	8
nozh	2	5	0	1	0	0	0	8
pup	7	5	5	2	1	0	0	20
petch'	5	4	7	1	1	0	0	18
pen'	7	4	5	3	3	0	0	22
pet'	6	6	3	1	1	0	0	17
parta	5	3	2	2	0	0	0	12
pasta	2	3	3	1	0	0	0	9
palka	5	2	2	0	1	0	0	10
papa	6	3	2	2	0	0	0	13
rut'	4	5	0	0	1	0	0	10
rosa	6	5	0	2	0	0	0	13
sosat'	7	4	1	2	1	0	0	15
rak	2	2	0	0	0	0	1	5
sup	6	4	4	2	0	0	0	16
skakat'	6	5	3	0	0	0	0	14

(table continues)

Word	Number of Errors at Presentation Level 20dB	26dB	32dB	38dB	44dB	50dB	56dB	Total
shatchok	5	4	2	2	0	0	0	13
spor	7	6	4	3	0	1	0	21
sest'	6	5	2	4	1	0	0	18
stena	5	6	3	1	0	0	0	15
sem'	5	3	3	2	1	0	0	14
set'	5	6	6	4	3	1	0	25
syr	4	3	2	0	0	1	0	10
spina	6	6	1	2	0	0	0	15
sip'	7	6	4	7	1	0	0	22
sok	4	4	3	1	0	1	0	13
sled	7	5	1	0	1	0	0	14
slon	4	0	1	1	0	0	0	6
sol'	7	1	3	1	1	0	0	13
sneg	7	3	2	1	0	0	0	13
son	6	3	4	1	1	0	0	15
syn	6	6	5	3	1	0	0	21
tetja	3	4	4	2	0	0	0	13
syt	5	4	3	1	0	0	0	13
tetch'	6	6	5	3	1	1	0	22
ten'	5	6	2	5	0	1	0	19
tcena	4	3	4	2	0	1	0	15
shit'	3	5	1	1	0	0	0	10
shag	7	3	2	0	0	0	0	12

To evaluate the effects of phonetic similarity of words within foils on the performance on certain test items, each foil was ranked according to the degree of acoustic similarity between the items. A score of 2 was assigned to minimally varied alternatives; a score of 1 one was given to the words varying in two phonemes; scores of 0.5 were assigned to phonetically similar, but not exactly rhyming alternatives. Total phonetic similarity scores were calculated for each foil and are included in Table 2. Mean percent correct performance for the six foils that received a score of 8 (four minimally phonetically varied alternatives) and the four foils that received the smallest phonetic similarity score of 2.5 was compared. Figure 3 illustrates the psychometric functions calculated separately for the six minimally phonetically varied (open circles) and the four maximally phonetically varied (open squares) four-word groupings. The mean percent-correct performance for maximally varied foils were 31% at 14 dB SPL, 53% at 20 dB SPL, 69% at 26 dB SPL, 87% at 32 dB SPL, 93% at 38 dB SPL, 98% at 44 dB SPL, 98% at 50 dB SPL, and 99% at 56 dB SPL. For the minimally varied foils, the mean percent correct performance was 26% at 14 dB SPL, 41% at 20 dB SPL, 56% at

26 dB SPL, 75% at 32 dB SPL, 92% at 38 dB SPL, 96% at 44 dB SPL, 98% at 50 dB SPL, and 99% at 56 dB SPL. The psychometric functions for both minimally and maximally varied groups of foils yielded essentially similar slopes of 2.7%/dB between 30 and 80 percent correct points, but were uniformly displaced by 2.56 dB as calculated using the third-order polynomials fitted to the functions. Both functions converged at presentation levels above 38 dB SPL, where the ceiling effects were observed for all foils. Maximally varied foils demonstrated better performance at every level of presentation, since more differential auditory cues were available to a listener. This was consistent with findings of Wilson and Antablin (1982).



<u>Figure 3.</u> Phychometric functions for the minimally (open circles) and maximally (open squares) phonetically varied response foils.

To evaluate the effect of syllable length on performance, percent correct scores of monosyllabic and bisyllabic foils were averaged and compared to each other. Figure 4 illustrates the psychometric functions calculated separately for 14 monosyllabic (open squares) and 11 bisyllabic (open circles) four-word groupings in the closed-set conditions. Similar to relationships of minimally and maximally varied test items, slopes of monosyllabic and bisyllabic psychometric functions were nearly identical at 2.8%/dB and 2.9%/dB, respectively. The functions also were displaced uniformly by 2.85 dB as calculated using the third-order polynomials fitted to the functions. The performance for syllables was consistently better, with mean percent-correct performance of 34% at 14 dB SPL, 55% at 20 dB SPL, 69% at 26 dB SPL, 86% at 32 dB SPL, 97% at 38 dB SPL, 99% at 44 dB SPL, 98% at 50 dB SPL, and 99% at 56 dB SPL. With monosyllabic foils score of 24% at 14 dB SPL, 45% at 20 dB SPL, 56% at 26 dB SPL, 76% at 32 dB SPL, 90% at 38 dB SPL, 98% at 44 dB SPL, 98% at 50 dB SPL, and 99% at 56 dB SPL were obtained. Performance with monosyllabic foils was also more varied compared to bisyllables, with standard deviations of 11 to 15 (9 to 7 for the bisyllables).

Apparently, different level of phonetic information redundancy in the monosyllabic foils created more inter-subject and inter-foil variability.

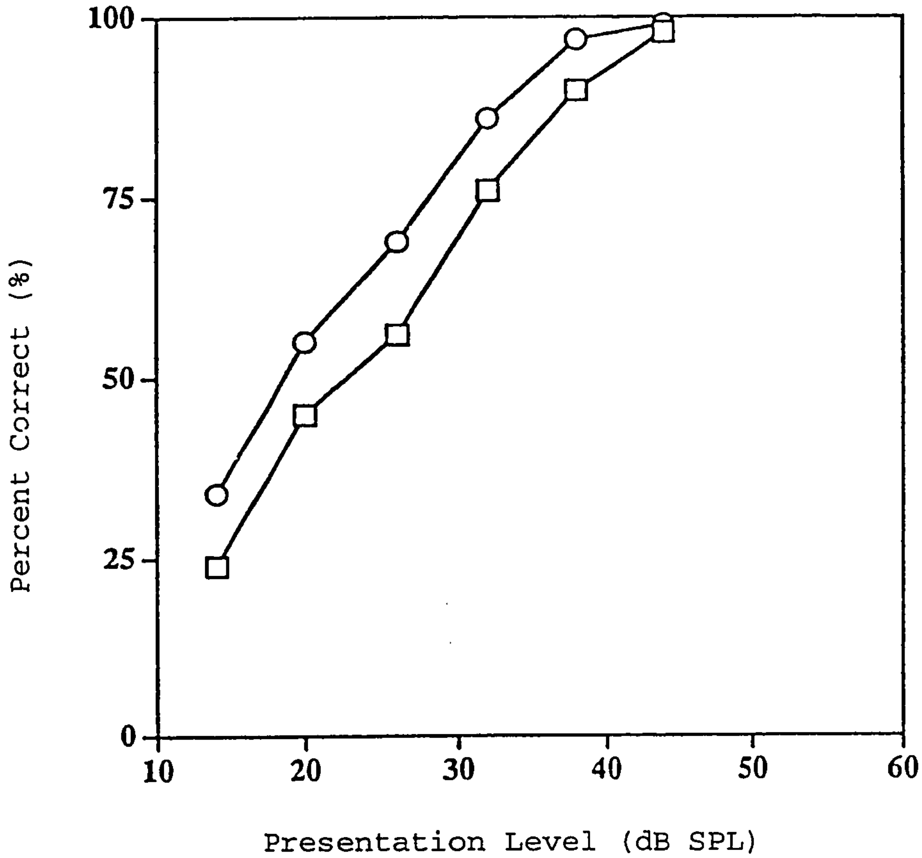


Figure 4. Phychometric functions for the monosyllabic (open squares) and bisyllabic (open circles) response foils.

The relationship between syllable length and phonetic similarity and performance patterns confirmed the established view on auditory discrimination tasks: the length of a word is directly proportional to the number of phonetic contextual clues available to a listener and, thus, to ease of discrimination (Hirsh et al., 1952; Grace, 1992). Additionally, minimally phonetically varied items in four alternatives forced-choice word identification tasks are more difficult to discriminate than more dissimilar items (Wilson and Antablin, 1982). Initial or final rhyming patterns appeared to have no significant effect on individual foil performance; a similar amount of confusions was made between initially rhyming and finally rhyming alternatives.

To evaluate the relative difficulty of the individual target words in response foils, a qualitative analysis of individual patterns of confusions was undertaken. Additionally, such analysis provided some insights into the origins of confusions in the closed-set condition. Data from Tables 9 and 10 were used for this analysis. Specifically, some confusions were made consistently between a pair of words in a foil (i.e., "marka"[post-stamp] and "maslo"[butter] were confused more often than much more closely phonetically corresponding "marka" and "maska"[mask] or "maslo" and "maska"). The most common and consistent confusions included "maslo"[butter] and "marka"[post-stamp] in foil 11, "kom"[snowball] – "kol" [stake], "kom" – "kot" [cat] in foil 25, "lapa" [paw] – "lampa" [lamp] in foil 19, "parta" [desk] – "pasta" [toothpaste] in foil 12, "osa" [wasp] – "rosa" [dew] in foil 10, and "nos" [nose] – "notch" [night] in foil 5.

It is possible that combination of relative difficulty of the pictures in a foil and/or cognitive strategies used by the subjects to select a response in near-absence of auditory cues (see section below) affected the performance in the forced-choice closed-set paradigm. No systematic phonetic influences were observed in these confusion patterns. Foils No. 4, 7, 8, 14, 20, 22 and 24 demonstrated non-discriminative pattern of confusions, where all four words in a foil were equally likely to be confused with each other. The individual percent-correct performance for these foils demonstrated slower growth than the mean. Not surprisingly, these foils were comprised of monosyllabic words that are rich in fricatives. These foils, therefore, were especially difficult, yet they also yielded near-perfect performance scores at levels above 38 dB SPL. Some individual words in a foil were likely to be confused with any other item in that foil, yet its three alternatives were easier to identify. Such words included "notch" (night) in foil 5, "maslo" (butter) in foil 11, "d'ad'a" (uncle, man) in foil 21, "kiska" (she-cat) in foil 16, "drug" (friend) in 18 and "pup" (navel) in foil 8. In foil 14, the word "zver'"(animal) was missed 29 times, making it the most commonly missed word in the closed-set condition. The words commonly missed in closed-set conditions words were not necessarily the most commonly missed in an open-set condition, yet a correspondence in error patterns between the conditions was observed. The above-mentioned word "zver'" was also among the most commonly missed in the open-set condition; words containing sibilant and affricate sounds were often missed in both conditions. It was hypothesized that in cases when visual/cognitive and contextual clues were sufficient to counteract phonetic uncertainty, target items yielded better relative performance in the closed-set conditions; words most commonly missed in open-set condition were not the most commonly missed in the closed-set condition. In order to evaluate this hypothesis and to assess the cognitive aspects of the closed-set picture-pointing task, subjects were asked to comment on the adequacy of visual representation of the test items at the completion of the test. The following section describes the procedure and results of this questionnaire.

Cognitive Aspects of Experimental Paradigm

The relationship between cognitive and visual cues to the performance of the subjects in a picture-identification task was noted by a number of researchers (Comstock and Martin, 1984; Wilson and Antablin, 1980). To assess (albeit informally) the cognitive and visual processing constrains on the closed-set picture-pointing Russian Picture-Identification Task, the subjects were requested to answer the following questions while each response foil was being shown to them again after the completion of the test:

1. Can you name each of the four objects or actions depicted on the screen?

2. Does the picture of each object or action resemble your mental representation of this object/action? If not, how would you represent it on screen?
3. Was the word represented by this picture evident to you before you actually heard it (or were able to hear) during the test?
4. Did you use the elimination strategy ("three other pictures can not represent this word, then it must be this picture") for any of the pictures on the screen?
5. If you did not hear the word and had to guess "at random," did you notice which picture of these four were you likely to choose? Can you tell why?

The responses to this questionnaire were scored on the separate blank scoring sheet attached to the test scoring sheets.

Overall analysis of the subjects' response indicated that when guessing in the absence or near -absence of auditory cues on the sub-threshold test levels, subjects appeared to select the answer based on the visual features of the pictures. In most cases, the subjects were inclined to make the "easiest" choice based on complexity, level of abstraction, number of distractions, and other cognitive aspects of the images. For example, in foil # 1, subjects were more likely to point at the picture of a poppy ("mak") or lobster ("rak") than to the pictures of two bottles of nail-polish ("lak") or a walking man ("shak"), since the former were bright color drawings of single objects relatively devoid of small details.

The pictures representing actions (i.e. "myt'"[wash], "krast'"[steal] or "sosat'"[suck]) or action-related nouns (i.e. "spor"[argument], represented by a picture of two people pointing fingers and shouting at each other, or "shak"[stride], represented by a picture of a walking man) contained more detailed and abstract features and were least likely to be selected when subjects were to guess the target word.

When asked to identify the picture in the absence of the auditory target, most subjects reported having trouble identifying the word "blisko" ("near") represented by a close-up of a box on a background of many boxes shown in perspective. The picture for "lak" ("nail varnish") -- a very common Russian word and object -- presented problems to men, but not to women. The pictures for human relationships, like "friend," "uncle," "father," were reported by some subjects as difficult to identify and/or distinguish. Yet no picture was uniformly reported as inadequate by all subjects; almost all subjects reported idiosyncratic problems. One subject identified a picture for "onion" as garlic, another female subject objected to the representation of the word "bake" as a woman making dough, reasoning that baking and making dough were separate actions. With these exceptions, subjects reported that the pictures adequately represented the target words.

It appeared from the qualitative analysis that, in cases when acoustic cues were ambiguous or missed entirely, the subjects were more likely to select images based on the list amount of cognitive activity required (see number of errors). As indicated above, selection process was influenced primarily by complexity of images, level of abstraction of image representing the word, and by the relationship between the images comprising the picture response foil. However, since clinically the test is administered at the supra-threshold levels when all alternatives are potentially audible, and an appropriate response could be chosen by elimination, those problems are of diminishing significance.

The clinical administration of the Russian Picture-Identification Task in the supra-threshold forced-choice closed-set conditions is recommended for evaluation of the Russian-speaking patient population to obtain an unbiased estimate of the word-recognition abilities of this population. Diagnostic value of this test remains to be established in clinical settings by assessing the patients with known etiologies of the hearing loss.

Chapter VI

Summary

In the multi-cultural and multi-lingual environment of today's audiological clinic, the need for a valid tool for assessing the word recognition abilities of native speakers of other languages is becoming imperative. A paradigm that permits an English-speaking audiologist to estimate the word recognition abilities of the non-English-speaking patient would fulfill this need. Such a paradigm, labeled a Picture-Identification Task, utilizes the auditory/visual format, in which a word recognition test is administered and scored automatically using a simple language-to-place transformation on a computer monitor, obviating the need for an audiologist to share a common language with the patient.

In the current study, auditory and visual portions of the Picture-Identification Task in the Russian language were designed and implemented. The resultant Russian Picture-Identification Task was normalized on twenty one young normal-hearing native speakers of Russian. Normative performance was obtained in open-set oral response conditions and closed-set picture-pointing conditions intended for clinical use. The obtained psychometric functions revealed increasing performance with increasing presentation level, and provided for the norms to be used in clinical decision making. An error analysis was performed for the closed-set data to establish the relationship between confusion patterns and the rhyming and syllabic properties of the materials. The length of the test items in a foil and the degree of phonetic similarity between the items in a foil were found to be the strongest predictors of the confusion patterns and overall number of errors in a foil. The normative performance on the Russian Picture-Identification Task was analyzed in the context of similar tasks (English and Spanish). The performance on the Russian task demonstrated good correlation between performance patterns with normative performance in these languages. Thus, the combination of monosyllabic and bisyllabic phonetically similar response alternatives chosen for the Russian Picture-Identification Task provides a roughly similar degree of contextual and psychoacoustic difficulty as the corresponding tests in English and Spanish, making possible the cross-language comparison of clinical norms. However, a similar study involving listeners with hearing impairments of known etiologies is needed to provide for the complete clinical description of the Russian Picture-Identification Task.

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APPENDIX A

Development of the Test Vocabulary

Characteristics of the Russian Language

The Russian language is a language of the Slavic language group and, although distantly related to the English language through a common ancestor (Indo-European meta-language), is characterized by a number of features distinctly different from English.

The alphabet that is used by the speakers of the Russian language is also known as Cyrillic and is shared by the number of the Slavic languages, such as Ukrainian, Bulgarian and Serbian. The Cyrillic alphabet is claimed to be invented by two Greek brothers, the "apostles of the Slavs," St. Cyril (or Constantine), for whom it was named, and St. Methodius in the ninth century AD. The earliest literature written in Cyrillic was the translation of the Bible and various religious writings by St. Cyril and St. Methodius. The symbols were based on the ninth century Greek uncial script. Since the Slavic languages were rich in sounds, 43 letters were originally provided to represent them. Most were derived from Greek letters or combinations of the Greek letters. Cyrillic letters for /ts/, /sh/, /ch/ and /shch/ were based on Hebrew alphabet, since the corresponding sounds were absent from Greek. ("Encyclopedia Britannica," 1986)

The modern Cyrillic alphabets – Russian, Ukrainian, Bulgarian and Serbian – have been modified somewhat from the original, generally by the loss of letters rendered obsolete by phonological changes in the language. Modern Russian and Ukrainian have 33 letters each, Bulgarian and Serbian 30 letters each. The current Russian alphabet adequately represents modern Russian phonetic inventory. The number of letters in a word correspond to the number of sounds, with the exclusion of two mute letters - "hard" and "soft" signs - that regulate hardness/softness of the preceding consonant. Therefore the length of the word in letters could be equated, with negligible discrepancies, to the length of the word in phonemes.

The phonetic inventory of Russian includes 7 monophthong vowels, no diphthongs and 20 soft consonants, 17 of which have hard cognates (Rezvetsova et al., 1989). The phonetic inventory of English includes 17 monophthong and 9 diphthong vowels and 25 consonants. Identical phonetic categories are present in Russian and English: vowels are classified as being front, central or back according to tongue position and as being high, mid or low according to tongue height; consonants are divided into the same general categories of stops, fricatives, affricates and sonorants. However, in addition to the "voice/voiceless" opposition existing in English (e.g. /b/ – /p/ voiced/voiceless cognates), the Russian language also has a "soft/hard" opposition (e.g. /b/ – /b'/ hard/soft cognates) and neutralizes the opposition 'voiced/voiceless' according to the position of the consonant in the word. For example Russian word "kot" [a cat] would be pronounced similar to the word "kod" [a code] due to the neutralization of the voiced/voiceless opposition at the end of the word.

In contrast to English, which favors CV and CVC types of syllables, Russian syllables have the general structure of either CCVC, CVCC or occasionally CVC. In combination with the morphologic composition of the words (the majority of the English words contain only one morpheme; two-morpheme words dominate in Russian), the differences in the syllabic composition contribute to the differences in word length in English and Russian.

Data from the word frequency dictionary (Amery and Kirilenko, 1986; Vakar, 1966) were used to compute the mean length of the "dictionary form" of a word in Russian. "Dictionary form" of the word was defined as Infinitive for the verbs, Nominative Case Singular for the nouns (forms bearing no grammatical markings). Mean length of the Russian words were computed at 9.3 letters.

In contrast to English, which has two cases for nouns and pronouns each: common and possessive and nominative and objective respectively, Russian has six cases for nouns, pronouns, adjectives and numerals: The Nominative, The Accusative, The Genitive, The Dative, The Instrumental and The Prepositional/Locative. The declension of the nouns, pronouns, adjectives, and numerals is achieved by changing the ending of the word with occasional change in stress and sometimes spelling. Similarly, Russian verbs are conjugated by changing the ending. The linguistic characteristics listed above were deemed important for understanding the development of the Russian Picture-Identification Task and of the problems confronted during its development.

Difficulties in Composing Test Vocabulary

The Russian language does not provide a sufficient amount of monosyllabic, CVC-structured words to compose the list of 100 rhyming and easily pictured words. The limited amount of monosyllabic words available are mostly prepositions, pronouns and modal verbs that could not be pictured unambiguously. The voiced/voiceless opposition at the end of Russian words is nonphonemic in Russian. The possible final rhyming scheme is therefore restricted, since words that differ graphically and lexically and that may be used as rhyming alternatives in verse (a "kot" – "kod" example cited above) could not be used for the purpose of the Picture-Identification Task.

The structure of Russian grammar places further restrictions on combining the foils. The richness of Russian rhymes is the result of the grammatical properties of the language: grammatical relationships are expressed through the conjugation and declension of the words via changes of words' endings. Thus, the "dictionary form" is only one of the numerous possible forms of a word, each of which can be rhymed with any other grammatical form of another word. However, for the purpose of this study, only "dictionary forms" were admissible, since it was impossible to illustrate any other grammatical form easily and unambiguously. Thus, the rhyming scheme suitable for the test was limited in comparison to the rhyming possibilities existing in the Russian language.

The construction of the Russian Picture-Identification task vocabulary required compensation for the above-listed characteristics of the Russian language and compliance with the restrictions imposed on the vocabulary items by the Russian phonology, grammar and rhyming scheme.

Principles of Russian Picture-Identification Task Vocabulary Construction

Various rhyming schemes were employed in composition of Russian target word groups. In this text, "rhyming" was used as a term describing close phonetical correspondence between pairs and groups of words. The correspondence of the group of words when only one sound constituted the difference and the number of sounds in words remained identical throughout the group will be called "Strict Exact Rhyming." The rhyming pattern when only one consonant sound constituted the difference and the number of sounds differs from word toward (when single consonant corresponds to consonant blend) was called "Non-strict Exact Rhyming." The part of the word that remained unaltered during exact rhyming was defined as a "core" structure. "First Order Approximation" is defined as a rhyming pattern such as apart from a variation of sounds constituting rhyming, there was variation of consonant sounds in the "core" structure in only one position. "Second Order Approximation" is defined as the variation of consonant sounds in the core structure at two positions. "Third Order Approximation" is defined as the variation of a vowel sound in the core structure, with exact consonant rhyming existing within the foil.

In view of the specific difficulties that the Russian language presents in selecting the four rhyming short words in the "dictionary form," a non-traditional approach was used in selecting the initial pool of target words. Instead of selecting the test items that satisfy the task criteria and then finding the rhyming alternatives for them, an attempt was made to first find combinations of four one- or two-syllable words which rhymed, and then successively eliminate the foils that did not satisfy the task criteria.

Two methods were used for the selection of test materials. In method A, tables of all Russian consonants and all Russian vowels were positioned in front of the native speakers. Each of the speakers was asked to consecutively combine all of the consonants with all of the vowels in CVC structures and pronounce those combinations loudly. If the combination was linguistically meaningful, it was recorded. If two or more rhyming combinations were obtained, the foil was constructed which contained four non-strict exact rhymes. The similar procedure was employed for the most frequently used consonant-vowel-consonant-vowel (CVCV) combinations.

In method B, "The Reverse Dictionary of the Russian Language" (Kolihin, 1984) was used. The dictionary lists Russian words in alphabetical order starting with the last letter. The body of the dictionary was scanned for the rhyming combinations. Similar to Method A, two or more rhyming combinations were included in a foil with non-strict exact rhymes. Using Methods A and B the initial pool of 54 four-word groupings were selected.

Selection of One Hundred Target Words

The final 25 foils were selected by successive elimination of the foils that didn't satisfy the following criteria: (a) test items must be common, familiar words; (b) test items must be easily pictured; (c) test items must be representative of the breadth of the phonemes in the language; (d) test items must be monosyllabic or bisyllabic to limit the effects of the linguistic/cognitive clues; and (e) test items must rhyme with three phonetically similar alternatives.

The first priority in selecting the 100 possible target words (25 four-word groupings or foils) was familiarity and frequency of the occurrence of the potential target words in everyday speech. An attempt was made to utilize special frequency dictionaries for establishing the frequency-of-occurrence indexes for the potential target words. However, the information provided by these dictionaries contradicted the current word usage on numerous occasions. Words related to political and economic structure of the communist state were represented as very common, thus contaminating the statistics; one of the most common words was "kolhoz" ("collective farm"); "perestroika" was not on the list.

These misrepresentations could be accounted for by two major factors. First, the available frequency dictionaries were out of date, having been written in the 1960's and strongly influenced by ideological factors. Second, in spite of the attempt to represent everyday common speech by analyzing plays and other dramatic works, these dictionaries failed to capture the vocabulary of real everyday life, drawing information mainly from printed texts.

Therefore, pilot studies were conducted to establish and quantify the frequency of occurrence of the potential target words in common everyday speech. The group of 18 pilot subjects (ages 5,9-80 years old) was given the list of all of the words in alphabetical order and was instructed to rate them according to the their frequency of occurrence in everyday speech. Children were asked to indicate whether they knew the meaning of the word. The familiarity and frequency of occurrence indexes were calculated for children (Children Familiarity Index - CFI) and for adults (Adult Familiarity Index - AFI). The cut-off criterion for inclusion in the potential 100 target words list was established as CFI = 1 and AFI = 2 (words that were familiar to young children and judged as occurring "frequently" or "not rarely" by the adult subjects). The words from the initial list that did not satisfy the criterion (CFI > 1 and AFI > 2) were eliminated from the list. After this elimination, however, only 11 foils that satisfied the criteria of familiarity and exact rhyming remained on the list. Therefore, the constraint of the rhyming scheme were relaxed, allowing words that were phonetically similar but not exact rhymes to be included on the list. Approximations of the First, Second and Third Order were allowed in the test. An additional list of 64 phonetically similar and rhyming words was composed. This additional list underwent similar frequency analysis involving the same group of subjects. The words from two lists were combined in the final list of 100 potential target words. Additionally, familiarity of the target words was verified by two sources: a list of 1000 most commonly used words in Russian (Amery and Kirilenko, 1986) and a list of 4000 most commonly used Russian words (Shansky, 1985). Seventy six percent of the words were found at least in one of the lists. Similar to frequency dictionaries, a political bias could have caused some of the everyday words to be replaced by political terms, which could account for 24% of very common test items not appearing in any list. However, these 24% were rated as "very common in everyday speech" by the overwhelming majority of pilot subjects. Table 3 illustrates the frequency of occurrence of the 100 target words. A "plus" sign indicates that the word is present in a list of the commonly used words in Russian; a numerical index corresponding to the mean of the familiarity ratings of 18 pilot study subjects is provided for the 24% of the words that do not appear in either of the printed lists.

The possibility that each of the potential target word could be adequately represented by a picture was tested in the following pilot experiment. A preliminary sketch-picture was made for each of the 100 words. The pictures were grouped according to rhyming scheme in 25 four-word groupings or foils. The same pool of subjects was requested to perform a closed-set pointing response to each of the stimulus words presented orally in a normal listening condition. A 100%-recognition score was obtained for all subjects.

Based on the pilot studies, we concluded that the 100 target words were familiar, commonly used, closely rhyming words that could be easily and unambiguously pictured. These

items constituted the target words for the Russian Picture-Identification Task.

Appendix B

RUSSIAN WORD-IDENTIFICATION TASK LIST A

transcription	translation	Russian original
1. brəsat'	throw	бросать
2. bliskə	near	близко
3. brat'	take	брать
4. vɨt'	howl	выть
5. gləsa	eyes	глаза
6. den'	day	день
7. dver'	door	дверь
8. det	grandfather	дед
9. dʲædə	uncle	дядя
10. det'i	children	дети
11. ʐuk	beetle	жук
12. ʐabə	toad, frog	жаба
13. zup	tooth	зуб
14. kup	cube	куб
15. kəvör	rug	ковёр
16. klətʃök	torn-out piece	клочок
17. kroʃə	bread crumb	крошка
18. kran	faucet, tap	кран
19. kom	snowball	ком
20. kost'	bone	кость
21. kobrə	cobra	кобра
22. korkə	bread crust	корка
23. lapə	paw	лапа
24. luk	onion	лук
25. lak	nail polish	лак
26. letʃ	lie down	лечь
27. miskə	bowl	миска

28. moʃkə	moth	мошка
29. markə	post stamp	марка
30. maslə	butter	масло
31. nol'	zero	ноль
32. noʃ	knife	нож
33. petʃ	bake	печь
34. pet'	sing	петь
35. pastə	tooth paste	паста
36. papə	father	папа
37. rəsa	dew	роса
38. rak	lobster	рак
39. skəkat'	jump	скакать
40. spor	argument	спор
41. stɛnə	wall	стена
42. set'	net	сеть
43. spɛnə	back	спина
44. sok	juice	сок
45. slon	elephant	слон
46. snek	snow	снег
47. sɨn	son	сын
48. sɨt	full	сыт
49. ten'	shadow	тень
50. ʃɨt'	sew	шить

LIST B

transcription	translation	Russian original
1. babə	older woman	баба
2. bek	running	бег
3. brat	brother	брат
4. vnuk	grandson	внук
5. dvor	yard	двор
6. druk	friend	друг
7. dʑtel	woodpecker	дятел
8. ʑetʃ	burn	жечь
9. ʑenə	wife	жена
10. zver'	animal	зверь
11. krəvat'	bed	кровать
12. kiskə	kitten	киска
13. kəsa	braid	коса
14. kəst'ör	fire	костёр
15. koʃkə	she-cat	кошка
16. koftə	jacket	кофта
17. krast'	steal	красть
18. kol	stake	кол
19. kot	cat	кот
20. listjə	leaves	листья
21. lampə	lamp	лампа
22. loʃkə	spoon	ложка
23. len'	laziness	лень
24. mɨt'	wash	мыть
25. mak	poppy	мак
26. mamə	mother	мама
27. maskə	mask	маска

28. noʃkə	foot	ножка
29. nos	nose	нос
30. noʧ	night	ночь
31. əsa	wasp	оса
32. pup	navel	пуп
33. pen'	tree-stump	пень
34. partə	desk	парта
35. palkə	stick	палка
36. rɨt'	dig	рыть
37. səsat'	suck	сосать
38. sup	soup	суп
39. səʧtök	moth net	сачок
40. ses't'	sit down	сесть
41. sem'	seven	семь
42. sɨr	cheese	сыр
43. sɨp'	pour (Imper.)	сыпь
44. slet	footprint	след
45. sol'	salt	соль
46. son	sleep	сон
47. totə	aunt	тётя
48. tetʃ	leak	течь
49. tsɛnə	price	цена
50. ʃak	step	шаг

RUSSIAN PICTURE-IDENTIFICATION TASK
English Transcription and Translation

1. ʃak step	mak poppy	rak lobster	lak nailpolish
2. mɨ̈ț wash	rɨț dig	vɨț howl	ʃɨț sew
3. ʒetʃ burn	petʃ bake	tetʃ leak	letʃ lie down
4. d̦eņ day	țeņ shadow	p̦eņ tree-stump	ļeņ laziness
5. nos nose	noļ zero	notʃ night	noʃ knife
6. tsɛna price	ʒɛna wife	stɛna wall	spɛna back
7. sok juice	soļ salt	son son	slon elephant
8. zup tooth	kup cube	sup soup	pup navel
9. korkə bread crust	koʃkə she-cat	koftə jacket	kobrə cobra
10. kəsa braid	rəsa dew	əsa wasp	gləsa eyes
11. mamə mother	markə post-stamp	maskə mask	maslə butter
12. pastə tooth-paste	palkə stick	partə desk	papə father

13. krəvaṭ	skəkaṭ	brəsaṭ	səsaṭ
bed	jump	throw	suck
14. dveṛ	zveṛ	dvor	spor
door	animal	yard	argument
15. kəṿör	kəsṭör	sətʃök	klətʃök
carpet	fire	moth-net	torn-out piece
16. bliskə	miskə	lisṭjə	kiskə
near	bowl	leaves	kitten
17. ḍet	ḅek	snek	slet
grandfather	running	snow	footprint
18. vnuk	ʒuk	luk	druk
grandson	beetle	onion	friend
19. lapə	lampə	babə	ʒabə
paw	lamp	older woman	toad
20. brat	braṭ	kran	krasṭ
brother	take	faucet	steal
21. ḍæḍə	ḍæṭəl	ṭöṭə	ḍeṭi
uncle	woodpecker	aunt	children
22. sɨn	sɨr	sɨt	sɨp̣
son	cheese	full	pour(imper.)
23. loʃkə	moʃkə	kroʃkə	noʃkə
spoon	moth	bread crumb	foot
24. seṃ	seṣṭ	p̣eṭ	ṣeṭ
seven	sit down	sing	net
25. kol	kom	kot	koṣṭ
stake	snowball	tomcat	bone

Appendix C

The Equations of Psychometric Functions for English, Spanish and Russian Picture Identification Task

The following equations were generated to represent the psychometric functions for English, Spanish and Russian Picture Identificatin Tasks and the NU-6:

1. English Picture-Identification Task

 a. open-set condition

$$y = -\ 0.007x^3 + 0.560x^2 - 10.858x + 53.819$$

 b. closed-set condition

$$y = -\ 0.009x^3 + 0.774x^2 - 16.631x + 100.913$$

2. Spanish Picture-Identification Task

 a. open-set condition

$$y = -\ 0.005x^3 + 0.478x^2 - 10.497x + 59.580$$

 b. close-set condition

$$y = 0.000x^3 - 0.021x^2 + 1.438x + 44.823$$

3. Russian Picture-Identification Task

a. open-set condition

$$y = -0.003x^3 + 0.264x^2 - 5.045x + 18.694$$

b. closed-set condition

$$y = -0.001x^3 + 0.049x^2 + 2.222x - 8.411$$

4. NU-6

a. open-set condition

$$y = -0.005x^3 + 0.452x^2 - 8.402x + 37.847$$

b. closed set-condition

$$y = 0.000x^3 - 0.141x^2 + 11.324x - 144.835$$